Growth Through Creation and Destruction of Supply Chains

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Abstract

We study the consequences of supply link formation and destruction at both the microeconomic and macroeconomic level. At the microeconomic level, we show, using detailed Belgian data, that exits by upstream firms raise their downstream buyer’s price, and show that our estimates can be used to directly calibrate the microeconomic value of innovation in both expanding variety and Schumpeterian growth models. In expanding variety models, this is the “love-of-variety” and in Schumpeterian models this is the innovation “step-size.” At the macroeconomic level, we develop a framework for computing how churn in supply chains, driven by either creative destruction or expanding varieties, propagates through input-output connections to affect measured aggregate growth. At both the microeconomic and macroeconomic level, we find that the creation and destruction of supply linkages between firms have very strong effects.

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1 Introduction

This paper studies the consequences of supply link formation and destruction at both the microeconomic and macroeconomic level. At the microeconomic level, we study how exogenous exits of suppliers affect the prices of downstream firms. We show that, in both expanding varieties models, like Dixit and Stiglitz (1977) or Romer (1987), and Ricardian models of creative destruction, like Aghion and Howitt (1992), the benefits of innovation to the buyer of a new supplier are summarized, locally, by the change in the area under the demand curve caused by the innovation relative to expenditures. In expanding variety models, this surplus is called the “love-of-variety” effect, whereas in creative destruction models it is the innovation “step-size.” Our analysis unifies these concepts and shows how this important statistic can be identified in production.1

Most models of creative destruction and expanding varieties focus on final consumption, where this change in surplus is not directly measurable because marginal utility is not observable. In these cases, researchers typically rely on very indirect evidence to discipline this statistic in their models. For example, in expanding varieties model, estimates of the price elasticity of demand or the elasticity of substitution, which depend on the curvature of demand at a point, are used to discipline the change in surplus from new varieties. While these are linked under a CES demand system, more generally, the surplus from new varieties need not be related to the price elasticity of demand in any way. Similarly, in Schumpeterian models of creative destruction, the step-size between the best and second-best supplier is disciplined by indirect inference via matching moments on, e.g., firm employment dynamics, patents, and growth (see, e.g., Garcia-Macia et al., 2019 and Akcigit and Kerr, 2018). In general, researchers are forced to rely on these indirect methods because directly measuring the change in surplus is impossible for a consumer: marginal utility is unobservable. In our context, where we focus on creation and destruction of supply linkages, the counterpart to marginal utility is marginal cost, and we can infer the change in surplus for a downstream firm by using changes in their prices.

We identify the change in surplus by regressing changes in prices charged by downstream firms on (instrumented) supplier exits. We show that, in an expanding variety model, this identifies the love-of-variety effect, and in a quality-ladder model, this identifies the quality/productivity step-size between competing suppliers. These results do not rely on strong functional form assumptions like CES.

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1A parallel distinction exists in the international trade literature between expanding variety models, like Melitz (2003), and Ricardian models of creative destruction, like Eaton and Kortum (2002). Both of these models can be distinguished from models of firm dynamics with decreasing returns to scale, like Hopenhayn (1992), where consumers are indifferent between which firm they buy goods from.
To estimate the value of supplier churn, we use a detailed survey of manufacturing firms in Belgium called Prodcom. This survey contains price and quantity information for most manufacturing firms in Belgium and is administered by the National Bank of Belgium. We merge this data with firm-to-firm input-output linkage information from value-added tax returns. Using this tax information, we can observe, at annual frequency, most suppliers of the firms in Prodcom. To instrument for supplier exits, we predict supplying firms’ exits by interacting their short-term debt obligations with changes in an aggregate interest rate. The identification requirement is that changes in downstream firms’ prices are not systematically correlated with the short-term indebtedness of their suppliers, conditional on their own debt-obligations and other controls including the changes in prices of continuing suppliers.

We find that if 1 percentage point of a firm’s suppliers exit, then this raises the price that the firm charges by around 0.6 percentage points. In a CES expanding varieties model, this amount of love-of-variety corresponds to an elasticity of substitution of roughly 2.5. In a quality-ladder model, this corresponds to an innovation step-size of 60 log points. In other words, at the microeconomic level, the creation and destruction of supply linkages have strong effects on the prices firms charge.

At the macroeconomic level, we also develop an accounting framework for tracking how churn in firm-to-firm linkages affects measured aggregate output. To do this, we suppose that the elasticity of substitution between continuing and non-continuing suppliers is constant, and leverage the well-known insight from Feenstra (1994). Intuitively, we infer the change in prices due to churn in suppliers by using the change in the expenditure share on continuing suppliers. We then compute how these price effects are transmitted along existing supply chains from customers, to their customers’ customers, and so on down to the final consumers. This calculation requires knowing the elasticity of substitution between continuing and non-continuing suppliers. To estimate this elasticity, we depart from common practice in the literature and directly regress changes in continuing share of suppliers, instrumented with exogenous supplier exits, on prices. We find an elasticity of around 2.5, and show that this implies that more than half of the technological residual in a growth accounting exercise can be accounted for by the creation and destruction of supply linkages.

**Related literature.** Our paper is related to three different literatures. First, our analysis informs both Schumpeterian and expanding varieties models of entry and exit. On the one hand, in models of monopolistic competition with expanding varieties, following Dixit and Stiglitz (1977) and Krugman (1979), a key object of interest and source of welfare gains
is the so-called love for product variety. This effect, which has been theoretically studied extensively by Zhelobodko et al. (2012), Dhingra and Morrow (2019), Baqaee et al. (2020), Matsuyama and Ushchev (2020), amongst many others, emphasizes that the benefits and efficiency of entry often hinge on how much consumer surplus (area under the demand curve above the price) each firm generates for the consumer upon entry. Evidence on the size of this surplus is scant despite the central role it plays. In expanding variety models of economic growth, following the tradition of Romer (1987), this surplus is also the engine for generating long-run growth. On the other hand, in Schumpeterian models of creative destruction, how much each innovating firm improves upon the products that it destroys, which can also be thought of as the change in consumer surplus caused by the innovation, crucially affect the theory’s positive and normative implications. Our paper contributes to this literature by estimating the size of this surplus directly in the context of production.

The second literature our paper is related to is the one on production networks, particularly models with an extensive margin. For example, Baqaee (2018) and Baqaee and Farhi (2020) show that cascades of supplier entry and exit in production networks change how aggregate output responds to microeconomic shocks. The response of aggregate output to a microeconomic shock, in turn, crucially depends on the same notion of surplus as discussed above. The importance of the extensive margin of firm-to-firm linkages has also been emphasized and studied by Lim (2017), Tintelnat et al. (2018), Acemoglu and Tahbaz-Salehi (2020), Elliott et al. (2020), Kopytov et al. (2022), and Bernard et al. (2018). Studies by Jacobson and Von Schedvin (2015), Barrot and Sauvagnat (2016), Carvalho et al. (2021), and Miyauchi et al. (2018) have shown that shocks and failures to one firm are transmitted across supply chains and affect the sales and employment of other firms in neighboring parts of the production network. Huneeus (2018) and Arkolakis et al. (2021) study adjustment costs in link-formation between firms and their aggregate consequences using a structural model. Our paper complements this literature by providing direct estimates about the value of link formation at the microeconomic level. We use these microeconomic estimates to discipline an aggregate growth accounting exercise that quantifies the importance of link formation in aggregate growth.

Third, our paper is also related to a deep literature on correcting price indices to account for the entry and exit of goods. The macroeconomic and trade literatures on the importance of entry and exit, which traces its origins to Hicks (1940), has been greatly influenced by Feenstra (1994) who introduced a methodology for accounting for product entry and exit, or other types of mismeasurement, under a CES demand system. Broda and Weinstein (2006) apply this methodology to calculate welfare gains from trade due to
newly imported varieties.\textsuperscript{2} Broda and Weinstein (2010) compute the unmeasured welfare gains from changes in varieties in consumer non-durables. Using a similar methodology, Jaravel (2016) calculates the gains from consumer product variety across the income distribution.\textsuperscript{3} Aghion et al. (2019) build on this methodology to correct aggregate growth rates for expanding varieties and unmeasured quality growth. Instead, our macroeconomic exercise quantifies the importance of supplier entry and exit for measured growth. The CES methodology owes its popularity to its simplicity and nondemanding information requirements. Outside of the CES literature, Hausman (1996), Feenstra and Weinstein (2017), and Foley (2022) have provided alternative price index corrections that rely on less heavily parameterized demand systems. A common theme in this literature is to estimate price elasticities of demand and infer the value of entering and exiting products by integrating demand curves under parametric restrictions (e.g. linear or translog demand). Our approach differs from the literature in that we attempt to identify the area under the input demand curve directly through its effect on downstream prices rather than via implicit or explicit integration. Of course, our methodology cannot be applied to household demand since marginal utility is not directly observable.

\section{Value of Link Formation}

We start by considering the value of suppliers in partial equilibrium. Consider a producer with a constant-returns-to-scale production technology. This producer relies on a set of inputs and the price that it charges is

\[ P = C (\{p_i\}_{i \in N}, A) = C (p, A), \]

where \( C \) is the average cost function, \( p_i \) is the price of input \( i \), \( N \) is the set of all possible inputs, and \( A \) indexes technological parameters outside of the firm’s control. We denote the set of all input prices by \( p \). For simplicity, we assume that the downstream producer is perfectly competitive, but we relax this later.

\textsuperscript{2}Welfare gains from trade arising from expanding varieties are an integral part of quantitative trade and macro models (see e.g. Arkolakis et al. (2008), Bilbiie et al. (2012), and Alessandria et al. (2020)). Other work documenting observable implications of product-entry is Goldberg et al. (2010), who show that new imports after trade liberalization cause more domestic entry.

\textsuperscript{3}The methodology of Feenstra (1994) requires knowledge of the elasticity of substitution, which is typically estimated using data on expenditure switching. Blaum et al. (2018) use changes in firm revenues (and parametric assumptions on the production function and downstream demand) to estimate the elasticity of substitution between imports and domestic inputs. Blaum et al. (2018) do not need to take a stand on whether the price of imports is mismeasured due to love for variety or mismeasured quality. Gopinath and Neiman (2014) study the implications of imported input churning for measured productivity under a CES aggregator.
Our objective is to understand how turnover in suppliers, either adding or dropping links, or replacing existing suppliers affects the output price $P$ of the downstream firm in partial equilibrium (we extend to general equilibrium later). To this end, consider a change in the price of an input $i$ from $p'_i$ to $p_i$.

We begin by introducing two important pieces of notation. First, define the infra-marginal surplus ratio associated with a reduction in the price of the input, to be

$$\delta_i = 1 + \frac{\int_{p_i}^{p'_i} x_i(p) dp_i}{p_i x_i(p)},$$

where $x_i$ is the demand for input $i$. That is, $\delta_i$ is the area under the input demand curve divided by the expenditures on input $i$. Denote the expenditure share on each supplier by

$$s_i(p) = \frac{p_i x_i}{C(\{p_i\}_{i \in N}, A)},$$

where the denominator is total variable expenditures on suppliers.

Group suppliers into types $\theta \in \Theta$, where suppliers of the same type have the same expenditure share. Denote the per-supplier expenditure share to be $s_\theta$ and the mass of suppliers of type $\theta$ to be $M_\theta$.

We now consider how creative destruction, where old suppliers are replaced by better suppliers, and expanding varieties, where new suppliers are added into the input mix, affect the downstream firm’s price. We start with creative destruction before turning to expanding varieties. We show that the intuition underlying the benefits of creative destruction and expanding varieties is quite similar, and both hinge on the infra-marginal surplus ratio $\delta$ defined above.

**Creative Destruction.** Suppose that existing suppliers of type $\theta$ are replaced by new suppliers that charge lower prices. The price gap between the old and new supplier of a variety of type $\theta$ is $\log(\frac{p'_i}{p_i}) = Z_\theta \geq 0$.

**Lemma 1** (Creative Destruction). Given a mass $\Delta M_\theta$ of replaced suppliers of type $\theta$, we have

$$\Delta \log P \approx -s_\theta \Delta M_\theta (\delta_\theta - 1),$$

and $\delta_\theta - 1 \approx Z_\theta$. The approximation is to a first-order in $Z_\theta$.

In other words, the effect on the price of the downstream firm depends on the expenditure share of exiting suppliers $s_\theta \Delta M_\theta$ and on the infra-marginal surplus ratio of creative
destruction $\delta_\theta$. Moreover, the infra-marginal surplus is, to a first-order, related to the innovation step-size between the exiting suppliers and their competitors who replace them. Note that, if an existing supplier exogenously exits and is replaced by its best competitor (who charges a higher price) then the sign of $\Delta \log P$ in Lemma 1 flips.

Now, we turn our attention to a change in the number of varieties.

**Expanding Varieties.** To understand how the addition of new input varieties affects the price of the downstream firm, we use the HSA demand system introduced by Matsuyama and Ushchev (2017).\(^4\) In other words, the expenditure share for input $i$ is determined by some downward sloping function $s_i(\cdot)$:

$$s_i(p) = s_i\left(\frac{p_i}{D(p)}\right),$$

where $D(p)$ is a price aggregator defined implicitly by the equation

$$\int_N s_i\left(\frac{p_i}{D}\right)di = \int s_i\left(\frac{p_i}{D}\right)M_\theta d\theta = 1.$$

The price aggregator $D(p)$ controls expenditure-switching and, in general, is different to the price of the downstream output good $P$. The second equality lets $M_\theta$ denote the mass of varieties of type $\theta$, and groups inputs $i$ and $i'$ into a single type if they have the same price $p_i = p_i'$ and residual demand curve $s_i(\cdot) = s_i'(\cdot)$. Note that this demand system allows each firm type $\theta$ to face a potentially different residual demand curve, $s_\theta(\cdot) \neq s'_\theta(\cdot)$, and nests separable translog and CES demand as special cases. CES is the only case where changes in the price aggregator and output price are the same $\Delta \log D = \Delta \log P$.

Now, suppose that the mass of suppliers of type $\theta$ increases by $\Delta M_\theta$. When a new supplier $i$ starts selling to the downstream firm, it is as if the price of that input has fallen from $p'_i = \infty$ down to some finite level $p_i < \infty$. So, suppose that a mass $\Delta M_\theta$ of type $\theta$ suppliers are added as new suppliers for the downstream firm. This means that their prices fall from infinity down to the price $p_\theta$ of other type $\theta$ suppliers with non-zero demand.

For these newly entering varieties, using the structure of the HSA demand system, the infra-marginal surplus associated can be rewritten as

$$\delta_\theta = 1 + \frac{\int_{p_\theta}^{\xi_\theta} x_\theta(p)dp_\theta}{p_\theta x_\theta} = 1 + \frac{1}{s_\theta\left(\frac{p_\theta}{D(p)}\right)} \int_{p_\theta/D}^{\xi_\theta} \frac{s_\theta(\xi)}{\xi} d\xi,$$

\(^4\)The same results obtain for the HDIA (generalized Kimball) and HIIA demand systems, also discussed by Matsuyama and Ushchev (2017).
where \( x^*_\theta \) solves \( s_\theta(x^*_\theta) = 0 \).

**Lemma 2** (Expanding Varieties). For a mass \( \Delta M_\theta \) of new suppliers of type \( \theta \), we have the following first-order approximation

\[
\Delta \log P \approx -s_\theta \Delta M_\theta (\delta_\theta - 1).
\]

The approximation is to a first-order in \( \Delta M_i \).

**Graphical Intuition.** Intuitively, creative destruction or new variety creation in suppliers generates surplus for the downstream producer. The left panel depicts creative destruction, where the price of the input falls from \( p'_i \) to \( p_i \), and the right panel depicts the addition of a new variety whose price falls from infinity down to \( p_i \). In both cases, the infra-marginal surplus ratio is given by

\[
\delta_i = \frac{A + B}{B} \geq 1.
\]

Either way, if the downstream producer chooses to form a new link, it lowers the costs of production by an amount commensurate with \( \delta \). In fact, Lemmas 1 and 2 are equivalent to a first-order.

![Figure 1: Graphical illustration of changing suppliers. In both figures, the infra-marginal surplus ratio \( \delta_i \) is equal to \( (A + B)/B \).](image)

Lemmas 1 and 2 separately consider changes in the set of suppliers due to creative destruction and expanding varieties. The following proposition derives a first-order approximation of the price of the downstream firm that combines these forces, and also allows for
changes in continuing suppliers’ input prices and technology shocks.\(^5\)

**Proposition 1** (Combined Shocks). In response to changes in prices of inputs \(p\) and technology shocks, the change in downstream firm’s price is

\[
\Delta \log P \approx \sum_{i \in N} s_i \Delta \log p_i + \sum_{\theta \in \Theta} s_\theta \Delta M_\theta (\delta_\theta - 1) + \frac{\partial \log C}{\partial \log A} \Delta \log A,
\]

where the first-order approximation is in \(\Delta \log p_i\) for continuing suppliers, \(\Delta M_\theta\) for expanding varieties, and \(Z_\theta\) for creatively destroyed suppliers.

In the expression above, if \(\Delta M_\theta\) corresponds to a group of suppliers who are being replaced by a perfectly substitutable variety, as in models of creative destruction, then \(\delta_\theta - 1\) is the gap between the exiting supplier and its replacement. On the other hand, if \(\Delta M_\theta\) corresponds to a group of suppliers who are entering or exiting without replacement, as in models of expanding varieties, then \(\delta_\theta - 1\) is the area under the demand curve above the price relative to the sales of those suppliers. Proposition 1 motivates one of our empirical specifications that seeks to identify \(\delta_\theta - 1\).

**CES Example.** To build intuition, we now consider a specific CES example, which is a special case of the HSA technology defined above. Specifically, if we assume that \(s_\theta(x) = b_\theta x^{1-\sigma}\), then the cost function \(C(\cdot)\) is a CES aggregator and the share of expenditures on varieties of type \(\theta\) is given by

\[
s_\theta = b_\theta \left( \frac{p_\theta}{P} \right)^{1-\sigma},
\]

The change in downstream price of the output good is given by

\[
\Delta \log P = \frac{1}{1 - \sigma} \log \left( \sum_{\theta \in \Theta} b_\theta M_\theta \left( \frac{p_\theta}{P} \right)^{1-\sigma} \right).
\]

Then, we can write

\[
\delta_\theta = 1 + \frac{1}{s_\theta \left( \frac{p_\theta}{P} \right)} \int_0^\infty s_\theta \left( \frac{\xi}{P} \right) d\xi = 1 + \frac{1}{\left( \frac{p_\theta}{P} \right)^{1-\sigma}} \int_0^\infty \left[ \frac{1}{1 - \sigma} \left( \frac{\xi}{P} \right)^{1-\sigma} \right] d\xi = \frac{\sigma}{\sigma - 1} \geq 1.
\]

According to Proposition 1, the change in the price of the output good in response to a change in the mass of entrants of type \(\theta\) is given by

\[
\Delta \log P = -s_\theta \Delta M_\theta (\delta_\theta - 1) = -s_\theta \Delta M_\theta \frac{1}{\sigma - 1}.
\]

\(^5\)If the downstream firms’ markup changes, then this must be added to the expression in Proposition 1.
In other words, for CES, the infra-marginal surplus ratio, $\delta$, commonly referred to as the “love-of-variety” effect, is controlled by the same parameter that controls the price-elasticity of demand $\sigma - 1 = -\partial \log s_{\theta}/\partial \log p_{\theta}$. However, note that in general, $\delta$ and $\sigma$ need not be related. The former is related to the area under the demand curve, whereas the latter is related to the elasticity of the demand curve at a point.

Next, consider a case where some fraction $\Delta M$ of varieties of type $\theta$ are replaced by suppliers who sell at price that is $Z_{\theta}$ lower. An application of Proposition 1 yields

$$\Delta \log P = -s_{\theta} \Delta M_{\theta} (\delta_{\theta} - 1) = -s_{\theta} \Delta M_{\theta} Z_{\theta}.$$ 

Therefore, unlike the expanding varieties case, the change in the price is not directly tied to the elasticity of substitution $\sigma$.

**Comparison to Feenstra (1994).** The most commonly used method for estimating the gains from entry and exit is to assume that the cost function is CES and use an insight from Feenstra (1994). We compare Proposition 1 to the methodology of Feenstra (1994). To do this, assume that the cost function is HSA. For any continuing variety $i$, we can write

$$\Delta \log s_{i} \approx (1 - \sigma_{i}) (\Delta \log p_{i} - \Delta \log D),$$

where $\sigma_{i}$ is the price elasticity of demand for $i$ and $\Delta \log D$ is the change in the price aggregator. We can invert this equation to yield

$$\Delta \log D \approx \Delta \log p_{i} - \frac{1}{1 - \sigma_{i}} \Delta \log s_{i}.$$

That is, we can infer changes in the price index $\Delta \log D$ using information on the change in the expenditure share on $i$ and the elasticity of substitution. Under the CES functional form, every variety has the same price elasticity of demand $\sigma_{i} = \sigma$, and the change in the price aggregator is the same as the change in the price of output $\Delta \log D = \Delta \log P$. Hence, under CES, we can further write

$$\Delta \log P \approx \Delta \log p_{i} - \frac{1}{1 - \sigma} \Delta \log s_{i}, \quad (1)$$

which allows us to infer changes in the output price from knowledge of changes in sales shares and elasticities of substitution. In the expanding varieties model, we additionally have that $\delta - 1 = \frac{1}{\sigma - 1}$, so that the coefficient on $\Delta \log s_{i}$ is, coincidentally, the same as $\delta - 1$. However, outside of the CES functional form with expanding varieties, $1/ (\sigma_{i} - 1)$ need not
be related to $\delta_i - 1$. The former is related to the curvature of the demand curve at a point, whereas the latter is related to the change in the area under the demand curve induced by entry/exit. Furthermore, and more importantly, the change in the price aggregator $\Delta \log D$ need not be the same as the change in the welfare-relevant price index $\Delta \log P$ outside of the CES. Therefore, Proposition 1 is fundamentally different to (1), both the left-hand side and the right-hand side are different in general.

In Section 3, we discuss how, by imposing the CES functional form, we can additionally decompose aggregate technological progress in a general equilibrium environment with firm-to-firm linkages into an intensive margin, technology shocks transmitted through existing supply linkages, and an extensive margin, driven by creative destruction or expanding varieties.

In Section 4, we discuss our empirical strategy for understanding the microeconomic and macroeconomic importance of supplier churn. We first estimate the change in surplus accruing to downstream firms, $\delta$, by regressing changes in output prices on instrumented (exogenous) supplier exits. This identifies $\delta$, which is an important statistic of independent interest in the theory of economic growth. Second, assuming a CES functional form, we regress changes in output prices on instrumented changes in expenditure share on continuing suppliers. This identifies $\frac{1}{\sigma - 1}$ in (1) assuming that input demand between continuing and non-continuing varieties is CES. We then use this parameter to discipline our growth accounting exercise and decompose the importance of supplier churn for aggregate growth.

3 Framework for Aggregation

In this section, we provide a framework for growth accounting in the presence of churning firm-to-firm linkages and markups. We start by describing the general equilibrium environment in Section 3.1 and then show how to decompose aggregate output growth in Section 3.2. For this exercise, we impose that some inputs are aggregated via CES, this allows us to nest both expanding varieties and creative destruction at the same time and in a tractable manner.

3.1 Environment

Consider an economy consisting of a set of producers $N$. Each producer is assigned to a unique industry and the set of industries is denoted by $I$. There is a set of primary inputs
denoted by $\mathcal{F}$. A primary input is an input used by producers in $N$ that those producers do not themselves produce. In practice, the set $\mathcal{F}$ includes labor, capital, and imported intermediate inputs. With some abuse of terminology, we refer to elements of $\mathcal{F}$ as factors.\(^6\) A stylized representation is given in Figure 2 showing the flow of goods and services.

![Figure 2: Graphical illustration of the economy](image)

**Technology.** Producer $i \in N$ is a constant returns to scale production function in period $t$ given by

$$y_{i,t} = F_{i,t}(\{X_{ij,t}\}_{j \in I}, \{l_{if,t}\}_{f \in \mathcal{F}}).$$

In principle, we can capture non-constant-returns-to-scale at the producer level using producer-specific fixed factors. In the expression above, $l_{if,t}$ is factor input $f$ used by $i$ and $X_{ij,t}$ is a constant returns to scale bundle of intermediate goods from industry $J$ used by $i$. We assume this bundle is a CES aggregator across varieties of different inputs from industry $J$

$$X_{ij,t} = g_{ij,t}(\{x_{ij,t}\}_{j \in J}) = \left(\sum_{j \in J} \frac{1}{\sigma_{ij}} \left(\frac{x_{ij,t}}{\sigma_{ij}^{\sigma_{ij}-1}}\right)^{\frac{\sigma_{ij}-1}{\sigma_{ij}}}\right)^{\frac{1}{\sigma_{ij}-1}},$$

\(^6\)Commonly, factors are labor and capital but not imported intermediates. This is because in national income accounting, imported intermediate inputs are subtracted from total value-added. We treat imported intermediates differently for reasons that will become clear later.
where $x_{ij,t}$ is are inputs purchased by $i$ from another producer $j$ at time $t$. Here, $j \in J$ means that $j$ belongs to industry $J$. The elasticity of substitution among $J$ varieties purchased by $i$ is $\sigma_{ij} > 0$. We allow producer-pair-specific productivity shifters $\bar{x}_{ij,t}$ to change over time.\(^7\)

Given prices of each good $j \in J$, denoted by $p_{j,t}$, the shadow-value of the bundle of inputs from industry $J$ used by firm $i$, denoted by $P_{iJ,t}$, satisfies

$$P_{iJ,t}X_{iJ,t} = \sum_{j \in J} p_{j,t}x_{j,t}.$$ 

We say that good $i$ is a continuing good between $t$ and $t + 1$ if $y_{i,t} \times y_{i,t+1} > 0$.

**Final output.** Final output of good $i \in N$, denoted by $c_{i,t}$, is the quantity produced of $i$ that is not used by some $j \in N$ and is either consumed by households, used for investment, or sold as exports. The nominal value of final output is $E_t \equiv \sum_{i \in N} p_{i,t}c_{i,t}$.

Growth in real final output as measured in the data is the change in nominal final output deflated by the average price change of continuing goods,

$$d \log Y_t = d \log E_t - \sum_{i \in C_t} \frac{p_{i,t}c_{i,t}}{\sum_{j \in C_t} p_{j,t}c_{j,t}} d \log p_{i,t},$$

where $C_t$ is the set of continuing goods at time $t$. To calculate growth in real final output between two time periods, we chain $d \log Y$ over time:

$$\log Y_{t+T} - \log Y_t = \sum_{s=t}^{t+T} d \log Y_s.$$

### 3.2 Decomposing Growth

Denote total variable cost of producer $i$ in time $t$ by

$$TVC_{i,t} = \sum_{j \in I} P_{i,t}X_{ij,t} + \sum_{j \in F} w_{ij}I_{ij,t},$$

\(^7\)In general, we can think that each customer-input pair $ij$, producer $i$ can choose between alternative suppliers that produce perfect substitute versions of input $j$ with different qualities in a quality ladder. The downstream firm $i$ always purchases from the supplier with the lowest quality-adjusted price. In an expanding varieties model, the quality ladder consists of a single producer for each variety. We do not explicitly write down this additional nest to save on notation.
consisting of expenditures on factors and intermediate inputs. Then define the variable cost share of $i$ on industry $J \in I$ to be

$$\Omega_{iJ}^V = \frac{P_{ij,t}X_{ij,t}}{TVC_{i,t}},$$

and variable cost share on primary input $f$ to be

$$\Omega_{if}^V = \frac{w_{f,t}l_{if,t}}{TVC_{i,t}}.$$  

By Shephard’s lemma, the change in the price of a continuing good $i$ is, up to a first order,

$$d \log p_{i,t} = d \log \mu_{i,t} - d \log A_{i,t} + \sum_{J \in I} \Omega_{iJ}^V d \log P_{ij,t} + \sum_{f \in F} \Omega_{if}^V d \log w_{f,t},$$  

where $d \log \mu_{i,t}$ is the log change in markup, $d \log w_{f,t}$ is the change in the price of factor $f \in F$, and $d \log A \equiv \partial \log F_i/\partial t$.

To find $d \log P_{ij,t}$, we use Equation (1). Specifically, the share of expenditures by producer $i$ on intermediate input $j$ in total purchases on industry $J$ inputs is

$$\frac{P_{ij,t}X_{ij,t}}{P_{iJ,t}X_{ij,t}} = \bar{x}_{ij} \left( \frac{P_{ij,t}}{P_{iJ,t}} \right)^{1-\sigma_{ij}}.$$  

Divide inputs in industry $J$ used by producer $i$ into two sets: a subset of continuing suppliers of $i$ in industry $J$ between $t$ and $t+1$ (i.e. $x_{ij,t} \times x_{ij,t+1} > 0$), denoted by $C_{ij,t}$, and the rest (which may also include continuing goods).

The share of expenditures by producer $i$ on inputs in $C_{ij,t}$ in total purchases on industry $J$ inputs is

$$\frac{\sum_{k \in C_{ij,t}} p_{k,t}x_{ik,t}}{\sum_{j \in J} P_{ij,t}x_{ij,t}} = \left( \frac{P^C_{ij,t}}{P_{iJ,t}} \right)^{1-\sigma_{ij}},$$

where the price over goods in $C_{ij,t}$ is

$$P^C_{ij,t} = \left( \sum_{j \in C_{ij,t}} \bar{x}_{ij,t}p_{ij,t}^{1-\sigma_{ij}} \right)^{\frac{1}{1-\sigma_{ij}}}.$$  

If the set $C_{ij,t}$ is non-empty, the log change in the continuing goods’ expenditure share
between \( t \) and \( t + 1 \), is

\[
d \log \varepsilon_{ij,t} = \log \left( \frac{\sum_{j \in C_{ij,t}} p_{j,t+1} x_{ij,t+1}^{\sigma_j} / \sum_{k \in I} p_{k,t+1} x_{ik,t+1}}{\sum_{j \in C_{ij,t}} p_{j,t} x_{ij,t} / \sum_{k \in I} p_{k,t} x_{ik,t}} \right)
\]

\[
= (1 - \sigma_j) \left( \Delta \log P_{ij,t}^C - \Delta \log P_{ij,t} \right).
\]

The expression above can be used to solve for the change in the shadow price of the industry \( J \) bundle used by producer \( i \)

\[
d \log P_{ij,t} = d \log P_{ij,t}^C + \frac{1}{\sigma_j - 1} d \log \varepsilon_{ij,t}.
\]

Equation (7) shows that the change in the price of continuing goods at time \( t \) depends on changes in markups, changes in entry-exit, and changes in factor prices.

\[8\] Here, \( d \log A_{ij,t} = \frac{\partial \log \varepsilon_{ij,t}}{\partial t} + \frac{1}{\sigma_j - 1} \sum_{j \in C_{ij,t}} \sum_{k \in I} \frac{p_{j,t} x_{ij,t}}{p_{k,t} x_{ik,t}} d \log \varepsilon_{ij,t} \]
Finally, define the cost-based Domar weights of goods and primary inputs to be

\[ \tilde{\lambda} = b_t'(I - W_t)^{-1}, \quad \tilde{\Lambda} = b_t'(I - W_t)^{-1}W_t^F, \]

where \( b_{i,t} = p_{i,t}c_{i,t}/E_t \) is the budget share of good \( i \) in final expenditures. Revenue-based Domar weights of goods and primary inputs are given by

\[ \lambda_i = \frac{p_{i,t}y_{i,t}}{E_t}, \quad \Lambda_f = \frac{w_{f,t}L_{f,t}}{E_t}, \]

where \( \lambda_i \) and \( \Lambda_f \) include all sales accruing to \( i \) and \( f \), regardless of the use. That is, \( \lambda_i \) and \( \Lambda_f \) include expenditures on \( i \) and \( f \) that are used to satisfy fixed or variable input needs. Averaging (7) according to final demand shares yields the change in the aggregate output deflator. Subtracting the price deflator from nominal aggregate output growth yields the following proposition.

**Proposition 2 (Growth-Accounting with Entry-Exit).** The change in aggregate output is given, to a first-order, by

\[
d \log Y_t = \sum_{i \in C_t} \tilde{\lambda}_{i,t} d \log A_{i,t} + \sum_{f \in F} \tilde{\Lambda}_{f,t} d \log L_{f,t} + \sum_{i \in C_t} \tilde{\lambda}_{i,t} d \log \varepsilon_{i,t} \tag{7}\]

\[ - \sum_{i \in C_t} \tilde{\lambda}_{i,t} d \log \mu_{i,t} - \sum_{f \in F} \tilde{\Lambda}_{f,t} d \log \Lambda_{f,t}. \]

Proposition 2 breaks down changes in aggregate output growth into difference sources.\(^9\) To better understand the intuition for this result, it helps to consider some special cases. We use different special cases to isolate the different expressions in this formula.

**Corollary 1 (Neoclassical Economy without Entry-Exit).** For an efficient economy with no markups and no entry-exit, the change in aggregate output is

\[
d \log Y_t = \sum_{i \in N} \lambda_{i,t} d \log A_{i,t} + \sum_{f \in F} \Lambda_{f,t} d \log L_{f,t}. \]

That is, output growth is the sum of technology and external input growth weighted by sales. This is the neoclassical case considered by Solow (1957) and Hulten (1978). This

\(^9\)For counterfactuals, we need to be able to solve for changes in factor shares \( d \log \Lambda \). This requires modelling the details of fixed costs and entry decisions. However, conditional on changes in factor shares, we do not need to specify these details.
result continues to hold in a model with entry-exit as long as the elasticity of substitution among varieties is infinity and there are no markups.

**Corollary 2 (Neoclassical Economy with Entry-Exit).** Consider an economy with no markup where \( c_{ij} = \infty \) for every \( i \) and \( j \), and where firms potentially have decreasing returns to scale. Assume that new firms can enter by paying a fixed cost. Then the change in aggregate output is

\[
d \log Y_t = \sum_{i \in N} \lambda_{i,t} d \log A_{i,t} + \sum_{f \in F} \Lambda_{f,t} d \log L_{f,t}.
\]

That is, output growth is the sum of technology and external input growth weighted by sales. In other words, the neoclassical (no entry-exit) results extend to the model with fixed costs and an active entry margin. The crucial requirement is that the equilibrium remain efficient and continuously differentiable.

**Corollary 3 (Markups without Entry-Exit).** For an economy with no entry-exit, the change in aggregate output is

\[
d \log Y_t = \sum_{i \in N} \tilde{\lambda}_{i,t} d \log A_{i,t} + \sum_{f \in F} \tilde{\Lambda}_{f,t} d \log L_{f,t} - \sum_{i \in N} \tilde{\lambda}_{i,t} d \log \mu_{i,t} - \sum_{f \in F} \tilde{\Lambda}_{f,t} d \log \lambda_{f,t}.
\]

The first two terms measure the increase in output growth due to the increase in technology and inputs, holding fixed the allocation of resources, and the latter two terms measure the effect of changes in the allocation of resources. In an efficient economy, these reallocation effects have no effect on output due to the envelope theorem. Reallocations are beneficial if the reduction in factor prices, as measured by \(- \sum_{f \in F} \tilde{\Lambda}_{f,t} d \log \lambda_{f,t}\), outpace the increases in prices caused by markups \( \sum_{i \in N} \tilde{\lambda}_{i,t} d \log \mu_{i,t} \). Intuitively, beneficial reallocations, by making better use of scarce factors, make factors less scarce and boost overall production.

**Corollary 4 (Constant Non-Zero Markups and Zero Profits).** For an economy with constant markups, a single factor of production, and a zero-profit condition, we have

\[
d \log Y_t = \sum_{i \in C_t} \tilde{\lambda}_{i,t} d \log A_{i,t} + \sum_{f \in F} \tilde{\Lambda}_{f,t} d \log L_{f,t} + \sum_{i \in C_t} \tilde{\lambda}_{i,t} d \log E_{i,t}.
\]

Mechanically, constant markups means that \( d \log \mu_i = 0 \), and a zero-profit condition with a single factor implies that \( d \log \Lambda_f = 0 \). Substituting these into Proposition 2 yields the result.

In the expression above, the first two terms capture the mechanical changes in prices caused by technology growth and changes in factor inputs. The final term measures the importance of new varieties — if new varieties are introduced or destroyed in equilibrium in
response to shocks, then these will affect marginal cost of downstream firms, and through these changes in marginal costs, affect aggregate output. Intuitively, these varieties effects are especially powerful if they induce entry into nests where the elasticity of substitution, $\sigma_{ij}$, is low, and the cost-based Domar weights, $\tilde{\lambda}_{it}$, are large.

4 Empirical Strategy

We consider two specifications. The first identifies the microeconomic value of supplier creation and destruction, captured by $\delta$ in Propositions 1. The second estimates the relevant elasticity of substitution, $1/(\sigma - 1)$, between continuing and non-continuing suppliers, which in combination with an assumption of CES, allows us to decompose aggregate growth using firm-level input-output data, as in Proposition 2.

**Estimating $\delta$.** To estimate how changes in suppliers’ entry and exit affect the downstream price, we estimate

$$\Delta \log p_{it} = \alpha \times \Omega_{i,t}^V \times \text{exit share}_{it} + \text{controls}_{it} + \epsilon_{it},$$

where $\text{exit share}_{it} \equiv 1 - \frac{\sum_{J \in I} \sum_{j \in C_{i,J,t}} p_{j,t} x_{ij,t}}{\sum_{J \in I} \sum_{j \in C_{i,J,t}} p_{j,t} x_{ik,t}}$ where $C_{i,J,t}$ is the set of continuing suppliers from industry $J$ to producer $i$, and $\Omega_{i,t}^V$ is the variable cost share for producer $i$ across all industries. The coefficient of interest, $\alpha$, measures the impact on the downstream price of a change in the producer’s extensive margin of its suppliers. It is related to the statistic $\delta$ introduced in Section 2 in models of expanding varieties and creative destruction.

**Estimating $1/(\sigma - 1)$.** We consider a second specification to estimate the elasticity of substitution between continuing and non-continuing suppliers shaping the elasticity of aggregate output to changes in entry-exit imposing CES aggregators. We write equation (6) as

$$\Delta \log p_{it} = \beta \times \sum_{J \in I} \Omega_{i,J,t}^V \times \Delta \log E_{ij,t} + \text{controls}_{it} + \epsilon_{it},$$

where, recall, $\Delta \log E_{ij,t}$ is the log change in the expenditure share on continuing suppliers used by producer $i$ in industry $J$. The coefficient of interest, $\beta$, is equal to $1/(\sigma_{ij} - 1)$ under the assumption that $\sigma_{ij}$ is common for all $i$ and $J$. In our baseline estimation, we consider a single industry $J$. In sensitivity analysis, we group suppliers into 6 or 21 industries (and for each producer $i$ only include those industries for which there exist continuing suppliers).

\[\text{10With heterogeneity in } \sigma_{ij}, \beta \text{ captures a weighted average of } 1/(\sigma_{ij} - 1) \text{ across producers and industries.}\]
suppliers between time periods). In both of these regressions, for each producer \( i \), the set of continuing suppliers, \( C_{ij,t} \), only includes suppliers which report annual accounts.

Regressions (8) and (9) estimate different statistics but are related. Pooling all producers into one industry, \( d \log E_{i,t} = \log (1 - \text{entry share}_{it+1}) - \log (1 - \text{exit share}_{it}) \approx \text{exit share}_{it} - \text{entry share}_{it+1} \).

Whereas regression (8) is motivated by Proposition 1 under quite general aggregators over suppliers, regression (9) is derived imposing CES aggregators over suppliers.

A concern in estimating (8) and (9) using OLS is that the exit share and the change in continuing share can be correlated with the residual in each regression. Shocks to producer \( i \)'s productivity can cause entry or exit of its suppliers. Similarly, shocks to producer \( i \)'s productivity can be correlated with shocks to suppliers. We therefore instrument \( \Omega_{V,ij,t} \times \text{exit share}_{it} \) in equation (8) by \( \Omega_{V,ij,t} \times \widehat{\text{exit share}}_{it} \) and we instrument \( \sum_{J \in I} \Omega_{V,ij,t} \times d \log E_{ij,t} \) in equation (9) by \( \sum_{J \in I} \times \Omega_{V,ij,t} \times \text{exit share}_{it} \), where

\[
\widehat{\text{exit share}}_{it} = \sum_{j \in I} \sum_{j' \in I} \frac{p_{j,t}x_{ij,t}}{\sum_{j' \in I} p_{j',t}x_{ij',t}} \widehat{\text{exit}}_{jt},
\]

and \( \widehat{\text{exit}}_{jt} \) is a predictor of supplier \( j \)'s exit at time \( t \).

We predict firm exit using changes in interest rates and in exchange rates. Specifically, in stage-0 we regress the zero-one indicator of observed supplier \( j \) exit at time \( t \) on a cost shifter (\( j \)'s short term debt interacted by the interest rate at time \( t \)) and industry \( \times \) time fixed effects. When constructing \( \widehat{\text{exit}}_{jt} \), we exclude the fixed effects. In sensitivity we include in stage-0 a demand shifter given by \( j \)'s changes in exchange rates on its exports (the average of bilateral nominal exchange rate changes for producer \( j \)'s weighted by its exports across countries).

The key identification assumption in the 2SLS is that supplier exit induced by changes in short-term interest rate payments (conditional on industry \( \times \) time fixed effects and other time \( \times \) producer-level controls) is uncorrelated with downstream producer \( i \) productivity shocks.

\footnote{Both specifications imply similar estimates if entry shares of suppliers are uncorrelated with exit shares across producers and over time.}

\footnote{If changes in observed downstream prices do not properly reflect changes in quality, then we must also assume that the instrument is uncorrelated with unobserved (price-equivalent) quality changes of the downstream producer.}
5 Data

Our empirical analysis makes use of a rich micro-level data structure on production networks of Belgian manufacturing firms in the period 2002-2018. The data structure brings together information drawn from six comprehensive panel-level data sets: (i) the National Bank of Belgium’s Central Balance Sheet Office (CBSO), which we refer to as the annual accounts; (ii) the Belgian Prodcom Survey; (iii) the National Bank of Belgium’s B2B Transactions data; (iv) the International Trade data at the NBB; (v) the VAT declarations; and (vi) the Crossroads Bank of Enterprises (CBE). We now describe how we use these data to construct the different variables of interest.

Firm-level input-output network. We construct the network of domestic suppliers of Belgian firms using the NBB B2B Transactions data set. The confidential NBB B2B Transactions data set contains the values of yearly sales relationships among all VAT-liable Belgian enterprises for the years 2002 to 2018, and is based on the VAT listings collected by the tax authorities. At the end of every calendar year, all VAT-liable enterprises have to file a complete listing of their Belgian VAT-liable customers over that year. An observation in this data set refers to the sales value in euro of enterprise $j$ selling to enterprise $i$ within Belgium, excluding the VAT amount due on these sales. The reported value is the sum of invoices from $j$ to $i$ in a given calendar year. As every firm in Belgium is required to report VAT on all sales of at least 250 euros, the data has universal coverage of all businesses active in Belgium. More details of the B2B data are provided in Dhyne et al. (2015). We drop suppliers that produce capital goods, identified from the Main Industrial Groupings (MIG) Classification of the EU. To control for misreporting errors, we drop a transaction if its value is 10 times larger than the seller’s aggregate sales (which is reported separately). To avoid any influence of this procedure on our entry/exit analysis, we also drop the transaction of the same supplier-buyer pair in year $t-1$.

Firm inputs and sales. Firms’ variable inputs consist of purchases of intermediates, labor costs, and user cost of capital. Labor costs and intermediates purchases (the sum of domestic and foreign inputs) are reported in the annual accounts. Small firms do not have to submit purchases of intermediates, so we complete this information using the periodical VAT declarations for these firms. If total intermediate purchases reported in the annual accounts exceed the sum of imports reported in the international trade dataset and domestic intermediates purchased from other Belgian firms reported in the B2B dataset, we replace the prior by the latter.

We do not include goods purchased from other Belgian firms classified as capital goods
providers, and we drop imported goods that are classified as capital goods in the Broad Economic Categories (BEC) classification (BEC codes 410 and 521), as these goods are not considered part of the variable intermediate inputs bundle. We add the cost of capital, \( r \times K \), as an additional input, where \( K \) is the capital stock reported in the annual accounts and \( r \) is the user cost of capital. The user cost of capital is the sum of a risk premium (set as 5 percent), the risk-free real rate (defined as the corresponding governmental 10 year-bonds nominal rate minus consumer price inflation at that time period), and the industry-level depreciation rate, \( (1 - d) \times g \), where \( d \) is the industry level depreciation rate (defined as consumption of fixed capital as a ratio of net capital stock) and \( g \) is the expected growth of the relative price of capital at the industry level (defined as the growth in the relative price of capital computed from the industry-specific investment price index relative to the consumer prices index in each year).

Firms’ total sales are computed in the same way as input purchases. Firms’ sales are reported in their annual accounts. Small firms do not have to submit sales, so we must complete this information using the periodical VAT declarations for these firms. We replace sales reported in the annual accounts with the sum of exports reported in the international trade dataset and sales to other Belgian firms that are reported in the B2B dataset if the latter exceed the prior. We measure markups as the ratio of aggregate sales over aggregate inputs.

**Mergers and acquisitions.** One challenge with using data recorded at the level of the VAT identifier is the case of mergers and acquisitions, since this might blur our entry/exit analysis of suppliers. When a firm stops its business, it reports to the Crossroads Bank of Enterprises (CBE) the reason for ceasing activities, one of which is merger and acquisition. In such cases, we use the financial links also reported in the Crossroads Bank of Enterprises (CBE) to identify the absorbing VAT identifier and we group the two (or more) VAT identifiers into a unique firm. We choose (i) a VAT identifier that reports annual accounts, VAT declarations, and B2B transaction, and (ii) if multiple eligible VAT identifiers exist, the VAT identifier with the largest total assets. We use this head VAT identifier as the identifier of the firm. Having determined the head VAT identifier, we aggregate all the variables up to the firm level. For variables such as total sales and inputs, we adjust the aggregated variables with the amount of B2B trade that occurred within the firm, correcting for double counting. For other non-numeric variables such as firms’ primary sector, we take the value of its head VAT identifier. It is important to emphasize that we group VAT identifiers only for the corresponding cross-section (the year of the M&A and after), and not over the whole panel period.
**Output and input prices.** We construct changes in output prices for a subset of manufacturing firms using sales and quantity data from Prodcom survey data. The Prodcom survey data covers firms that produce goods covered by the Prodcom classification and that have at least 20 employees or 3,928,137 euro turnover in the previous reference year. Products are identified at the 8-digit level of the Prodcom (PC) classification, which is common to all EU member states. Sales values (in euro) and quantities are available at the firm-PC8-month level. Quantities are reported in one of several measurement units (over two thirds of observation are in kilograms; other units include liters, meters, square meters, kilowatt, and kg of active substance). We aggregate monthly observations to yearly values to match the other data sets.

Changes in output prices are obtained as log differences in unit values from year t-1 to t for all PC8 products. As unit values can be noisy, we trim the change in unit values at the 5-95 percentile level. For multi-product firms (defined as Prodcom firms that produce multiple PC8 products), changes in output prices for individual products are aggregated to the firm-level, with weights given by the revenue share of each product in the corresponding year.

We define labor use as full time employed and wages as total labor costs divided by labor use. The user cost of capital is constructed as described above. Change in input prices are constructed for each producer and year as log differences in unit values for imports and for domestic suppliers from Prodcom. The change in i’s input price index is a weighted average of price changes of inputs j bought by i weighted by their input share. For imports, this price shock is simply the change in unit values faced by i at the partner country - CN8 product level. As unit values can be noisy, we trim the change in unit values at the 5 – 95 percentile level. For domestic suppliers in the Prodcom data, the output price change of supplier j is used as the input price paid by i. For this subset of suppliers, we assume that producer i buys the full bundle of products of j if j is a multi-product firm. We then use the change in the firm-level output price index (a weighted average of price changes across all PC8 products of producer i).

We calculate for each producer the product of the short-term debt ratio (short-term debt over total liabilities reported in the annual accounts) and the change in nominal interest rate (1 month money market interest rate for the euro area).

To construct an export-weighted log change in exchange rate by producer and prices of imported inputs, we use data on export and imports from the Intrastat (intra-EU) and Extrastat (extra-EU) declarations for Belgium. Observations in this data set are at the firm-product-partner-year level. Products are defined at the 8-digit Combined Nomenclature (CN8) level, a 2-digit extension of the international 6-digit Harmonized System (HS) clas-
sification, and common to all member states in the EU. We exploit information on values and quantities to generate import prices as unit values, and obtain a price per kilograms and per secondary unit if available. At the CN8 level, most products’ import quantities are recorded in weight (kilograms). Depending on the particular product, some products’ quantities are also recorded in a secondary unit. All values are aggregated to the yearly level.

Sample of firms For the growth-accounting exercises, we consider non-financial corporations (we exclude self-employed and government entities) active in market industries (excluding the financial sector, Nace 2digits 64 to 66, and non-market sectors, nace 2digits 84 to 99). We only include continuing firms, that is firms with both sales and intermediates purchases larger than 1000 euros in two consecutive years. The matrix $W$ is constructed based on the network of domestic firms who meet these sample selection criteria.

Table 1 and Table 2 report basic statistics for this sample of firm (the latter table is restricted to contain at least one supplier that reports annual accounts).

For the price regressions, we further restrict the sample to firms in the Prodcom survey with positive labor and positive capital stock who have at least one continuing supplier with annual accounts (for which we are able to changes in the share of continuing goods), and for which the Prodcom sales is higher than 30% of the firm’s aggregate sales from the annual accounts (so that Prodcom is representative of overall sales). Table 3 provides the number of firms for every year $t$ between 2002 and 2007, as well as the fraction of firms that exit rate between $t$ and $t + 1$. The exit rate is much higher for small firms (those below the median size) and large firms.

6 Empirical results

Table 4 shows that short-term debt interacted with changes in the interest rate predict firm exits. We will use this exogenous variation to construct our instrument. Columns (2) and (3) break this down for firms smaller or larger than the median sales firm. The effect is stronger for small firms, meaning that our instrument is stronger for small firm exits than large ones. The final column shows how if a movement in exchange rates, weighted by export shares if firms are exporters, affect exits. Since exporters tend to be large firms that do not exit often, the exchange rate variable is not significant.

Estimating $δ − 1$. Table 5 reports baseline estimates in the price regression in Equation (8). The controls include industry $×$ time fixed effects, changes in domestic input prices and
Table 1: Coverage of growth accounting sample of firms

<table>
<thead>
<tr>
<th>year</th>
<th>(1) count</th>
<th>(2) value added</th>
<th>(3) % of agg.</th>
<th>(4) employment</th>
<th>(5) % of agg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>225293</td>
<td>117877</td>
<td>79%</td>
<td>1736</td>
<td>74%</td>
</tr>
<tr>
<td>2003</td>
<td>232834</td>
<td>130144</td>
<td>84%</td>
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<td>2004</td>
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<td>141466</td>
<td>86%</td>
<td>1729</td>
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<td>141161</td>
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<td>1745</td>
<td>72%</td>
</tr>
<tr>
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<td>258480</td>
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<td>73%</td>
</tr>
<tr>
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<td>141708</td>
<td>74%</td>
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<td>72%</td>
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<td>142397</td>
<td>72%</td>
<td>1833</td>
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<td>287599</td>
<td>145369</td>
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<td>1810</td>
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</tr>
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<tr>
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<tr>
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<tr>
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<tr>
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<td>185386</td>
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<td>1917</td>
<td>70%</td>
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<tr>
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<td>195098</td>
<td>81%</td>
<td>1960</td>
<td>71%</td>
</tr>
</tbody>
</table>

avg. growth (%) 3.4 3.3 0.8 1.1

Notes: The sample of firms used in this table are those used in the growth accounting exercise (continuing corporate non-financial firms continuing firms). % agg. is the share of value added and employment in the non-financial corporate sector reported in the national statistics.

in imported input prices by producer, changes in the wage and in the user cost of capital, and changes in the interest rate interacted with short-term debt over liabilities which we use in our instrument. We cluster at the firm level. Our baseline regressions do not weight observations.

The first column is the OLS, where changes in the continuing share of suppliers has a negative coefficient and is statistically insignificant. Of course, the OLS is subject to severe omitted variable bias. For one, shocks to continuing suppliers can affect the price both directly as well as indirectly by changing the share of continuing suppliers. In a similar vein, shocks to a consumer can affect markups and also trigger upstream entry-exit which could change the share of continuing suppliers.

Column (2) is the reduced-form regression of our exit instrument on the price. This column shows that an exogenous increase in supplier exits predicts an increase in the price of the downstream firm consistent with the idea that supplier exits raise downstream prices. However, the coefficient is difficult to interpret. Column (3) runs regression (8) using our
Table 2: Descriptive statistics

<table>
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<tr>
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<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>continuing supplier share</td>
<td>intermediates share</td>
<td>short-term debt ratio</td>
<td>number of suppliers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>level</td>
<td>mean</td>
<td>p25</td>
<td>p50</td>
<td>p75</td>
<td>count</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>0.30</td>
<td>0.61</td>
<td>0.84</td>
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<td></td>
</tr>
<tr>
<td>all</td>
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<td>-0.14</td>
<td>-0.01</td>
<td>0.11</td>
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<td></td>
</tr>
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<td>domestic</td>
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<td>0.81</td>
<td>0.92</td>
<td>0.99</td>
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<td>debt ratio</td>
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<td>0.34</td>
<td>0.62</td>
<td>0.85</td>
<td>4628332</td>
<td></td>
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<tr>
<td>all annual accts.</td>
<td>0.27</td>
<td>0.00</td>
<td>0.07</td>
<td>0.36</td>
<td>4529159</td>
<td>625</td>
<td>625</td>
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<tr>
<td>annual accts.</td>
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<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Notes: The sample of firms used in this table are those used in the growth accounting exercise (continuing corporate non-financial firms continuing firms) with at least one domestic supplier filling its annual account.

exit instrument on the whole sample with controls. The coefficient measures the strength of the extensive margin (which captures either love-of-variety or creative destruction). Under CES demand and expanding varieties, the point estimate of 0.708 implies an elasticity of substitution of roughly 2.5. Under creative destruction, the point estimate implies roughly a doubling in the quality or efficiency of suppliers that displace existing ones. Column (4) removes the controls and shows that our point estimates do not change much. The last two columns (5) and (6) repeat the same regression replacing price with a measure of marginal cost and markups on the left-hand side. We back out the markups from a measure of firm profits under the assumption of constant returns to scale. To get profits, we subtract total variable costs, including a measure of capital costs, from revenues. Columns (5) and (6) suggest that the changes in the price are primarily driven by changes in marginal costs and not markups.

**Estimating** $1/(\sigma - 1)$. Table 6 reproduces Table 5 for estimating equation (9). We use these results to calibrate the elasticity of substitution in the growth accounting results, since regression (9) does not need to take a stand on expanding varieties or creative destruction. The elasticity of substitution between continuing and non-continuing suppliers implied by these estimates is roughly 2.5.

Table 7 and 8 report sensitivity to the results in Table 6. Table 7 provides a series of sensitivity tests. The first column restricts the sample to single-product firms, and the second

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13 In a creative destruction model, if a supplier exits for exogenous reasons, then the buyer switches to the next-best alternative supplier who is one-step below. Hence, the increase in the buyer’s price identifies the step-size. Given our empirical strategy, which predicts exits of heavily indebted firms in response to macro interest rate shocks, this is how we interpret our results. On the other hand, if the existing supplier exits because it has been surpassed by its competitor, then the buyer’s price falls.
Table 3: Exit rates

<table>
<thead>
<tr>
<th>Year</th>
<th>Count</th>
<th>Exit rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>all</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>all</td>
<td>small</td>
</tr>
<tr>
<td>2002</td>
<td>226342</td>
<td>0.037</td>
</tr>
<tr>
<td>2003</td>
<td>237497</td>
<td>0.036</td>
</tr>
<tr>
<td>2004</td>
<td>247459</td>
<td>0.039</td>
</tr>
<tr>
<td>2005</td>
<td>252874</td>
<td>0.042</td>
</tr>
<tr>
<td>2006</td>
<td>261895</td>
<td>0.037</td>
</tr>
<tr>
<td>2007</td>
<td>270355</td>
<td>0.035</td>
</tr>
<tr>
<td>2008</td>
<td>279226</td>
<td>0.039</td>
</tr>
<tr>
<td>2009</td>
<td>287553</td>
<td>0.034</td>
</tr>
<tr>
<td>2010</td>
<td>291129</td>
<td>0.032</td>
</tr>
<tr>
<td>2011</td>
<td>299381</td>
<td>0.034</td>
</tr>
<tr>
<td>2012</td>
<td>309501</td>
<td>0.042</td>
</tr>
<tr>
<td>2013</td>
<td>307803</td>
<td>0.036</td>
</tr>
<tr>
<td>2014</td>
<td>315123</td>
<td>0.036</td>
</tr>
<tr>
<td>2015</td>
<td>317887</td>
<td>0.032</td>
</tr>
<tr>
<td>2016</td>
<td>326172</td>
<td>0.031</td>
</tr>
<tr>
<td>2017</td>
<td>333882</td>
<td>0.031</td>
</tr>
</tbody>
</table>

Notes: Number of continuing firms at t and fraction of firms that exit between t and t + 1 Small and large firms are those below and above the median sales firm.

and third columns exclude retail/wholesale trading suppliers and service firms from the set of suppliers. The coefficient raises when we exclude wholesale/retail trade suggesting that the exit of non-retail/non-wholesale trade suppliers is more costly to firms. However, by reducing the sample size, the first stage is weaker. Columns (4) and (5) disaggregates continuing suppliers into either 6 or 21 industries. This slightly raises the point estimates, but also raises standard errors. Finally, columns (6) and (7) drop the requirement that the continuing share be defined over only those suppliers who file annual accounts, including either all domestic firms or foreign suppliers. The point estimates are broadly similar and we cannot reject that they do not change.

Table 8 provides additional robustness tests. The first column reduces trimming, and columns (3)-(5) experiment with different fixed effects. Column (6) weighs observations by the logarithm of total sales of the producer.\textsuperscript{14} clusters at the industry by year level, rather than by firm, and column (7) includes exchange rate movements as an additional exogenous source of firm exits. We also consider The coefficients remain broadly similar.

\textsuperscript{14}Weighing by the level (rather than the logarithm) of sales renders that first stage insignificant. This is because suppliers of large firms do not exit as much in response to interest rate shocks.
Table 4: Predicting exit rates

<table>
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<th>(1) all firms</th>
<th>(2) large firms</th>
<th>(3) small firms</th>
<th>(4) 2 predictors</th>
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<td>debt $\times$ change int. rate</td>
<td>0.002***</td>
<td>-0.000</td>
<td>-0.001</td>
<td>0.002***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>exporter exchange rate</td>
<td>-0.017</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fixed effect</td>
<td>nace2$\times$year</td>
<td>nace2$\times$year</td>
<td>nace2$\times$year</td>
<td>nace2$\times$year</td>
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<td>2282026</td>
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7 Growth-Accounting Results

By assuming that demand for varieties is CES, and given our point estimates of the importance of supplier entry-exit, we can quantity the fraction of growth due to entry-exit following Proposition 2. For each producer, define the set of continuing suppliers to be all continuing suppliers, and not those that report also annual accounts.

![Figure 3: Growth accounting special cases](image)

We start with two special cases in Figure 3. The first panel is a traditional Solow-Hulten decomposition, where we assume away entry-exit effects, setting $\beta = 0$, that is, supplier entry-exit (extensive margin) is irrelevant, and assuming that all prices are equal to marginal cost. This breaks down overall growth into growth due to an increase in the
Table 5: Price changes and exit

<table>
<thead>
<tr>
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<th>(1)</th>
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<th>(4)</th>
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<th>(6)</th>
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<tr>
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<td>RF</td>
<td>2SLS</td>
<td>2SLS</td>
<td>2SLS</td>
<td>2SLS</td>
</tr>
<tr>
<td>exit share</td>
<td>0.000</td>
<td>0.708***</td>
<td>0.821***</td>
<td>0.762**</td>
<td>0.105</td>
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<tr>
<td></td>
<td>(0.003)</td>
<td>(0.235)</td>
<td>(0.288)</td>
<td>(0.332)</td>
<td>(0.146)</td>
<td></td>
</tr>
<tr>
<td>predicted exit share</td>
<td>21.791***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.935)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>controls</td>
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<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
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<td>43140</td>
<td>43140</td>
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Table 6: Price changes and continuing share

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<td>2SLS</td>
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<td>0.698***</td>
<td>0.597**</td>
<td>0.108</td>
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<td>(0.002)</td>
<td>(0.227)</td>
<td>(0.234)</td>
<td>(0.243)</td>
<td>(0.146)</td>
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</tr>
<tr>
<td>predicted exit share</td>
<td>21.791***</td>
<td></td>
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<td></td>
<td>(4.935)</td>
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Table 7: Price changes and continuing share: Sensitivity I

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<td></td>
<td>single product</td>
<td>ret., whole</td>
<td>services</td>
<td>6 ind.</td>
<td>21 ind.</td>
<td>all dom.</td>
<td>foreign</td>
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<tr>
<td>dlog cont. share</td>
<td>0.517*</td>
<td>0.749**</td>
<td>0.568**</td>
<td>0.702**</td>
<td>0.727**</td>
<td>0.863***</td>
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<tr>
<td></td>
<td>(0.272)</td>
<td>(0.359)</td>
<td>(0.224)</td>
<td>(0.291)</td>
<td>(0.316)</td>
<td>(0.327)</td>
<td>(0.175)</td>
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<td>fixed effects</td>
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<td>nace2×year</td>
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Table 8: Price changes and continuing share: Sensitivity II

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<td></td>
<td>additional exit predictor</td>
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<td></td>
<td>2.5% trim</td>
<td>alternative fixed effects</td>
<td>log weight</td>
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<td>0.636***</td>
<td>0.545**</td>
<td>0.773***</td>
<td>0.840***</td>
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</tr>
<tr>
<td></td>
<td>(0.221)</td>
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</tr>
<tr>
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<td>nace4×year</td>
<td>nace2 + year</td>
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quantity of factors and a residual term capturing the technological residual. In these figures, a substantial portion of aggregate growth, slightly less than half, is driven by unexplained technological growth. The second panel allows for firm-level markups. This figure shows that markups on average have risen over the sample, and factor shares have fallen. However, the reduction in factor shares, which capture changes in factor prices, does not offset the increase markups. In other words, since markups on average have risen faster than factor shares have fallen, this suggests that there has been a reallocation away from high-markup firms. This dampens productivity growth, which means that we need a stronger unexplained technological residual to explain the observed growth in output.

Figure 4: Growth accounting baseline results

Figure 4 allows for entry-exit. The first panel shows the results with $\beta = 0.3$, corresponding to an elasticity of substitution of 4, while the second panel shows $\beta = 0.5$, corresponding to an elasticity of substitution of 3 respectively. Both of these are conservative compared to our point estimates in Section 6 in the sense that they assign a slightly relatively smaller role to entry-exit than our point estimates suggested. Nevertheless, we find that the extensive margin of suppliers can explain a substantial fraction of the technology residual. Indeed, when $\beta = 0.5$, the role of the technology residual, intensive margin improvements for existing firms, has all but disappeared from the calculation, showing that almost the entirety can be attributed to the entry and exit of suppliers.

For comparison, Figure 5 calculates the missing growth in final demand, following Aghion et al. (2019), capturing the importance of entry-exit for final demand (which is unaccounted in real GDP). In the baseline case we weight industries by employment (as in Aghion et al. (2019)) and in an alternative case by final sales. The numbers are much smaller when compared to the importance of entry-exit in supply chains as captured by
8 Conclusion

This paper analyzes and quantifies the microeconomic and macroeconomic importance of creation and destruction of supply linkages. At the microeconomic level, we show that supplier exits have large effects on downstream firms’ prices and show that this can be used to directly calibrate the change in consumer surplus that a supplier exit triggers. In an expanding variety model, this captures the love-of-variety effect, whereas in a Schumpeterian model of creative destruction, this captures the innovation step-size. At the macroeconomic level, we show that supplier entry and exit can account for a large part of the unexplained technological residual in a Solow (1957)-style growth accounting exercise. Our results suggest that supplier entry and exit has large and important consequences for growth.

References


Matsuyama, K. and P. Ushchev (2020). When does procompetitive entry imply excessive entry?