Measuring trends and persistence in capital and labor misallocation

Jasper de Winter* & Maurice Bun*‡

De Nederlandsche Bank (DNB)
Econometrics and Modelling Department*
University of Amsterdam‡

KU Leuven, 7 June, 2019

Disclaimer: views expressed do not necessarily reflect official position of De Nederlandsche Bank
Introduction

Research question

- What is the extent and nature of misallocation of capital and labor in the Dutch economy, and how has it evolved over time?

Motivation

- Several papers misallocation is a serious problem and has increased since the Great Recession

Main contribution

- Extent previous research by analyzing nature, and persistence of misallocation by applying models from the earnings literature.
Main messages

Main take-aways from our study

- Misallocation of capital in the Netherlands has increased over the period 2001–2017;
- Misallocation of labor has remained more or less stable in our sample;

- Capital wedge is relatively large for small, highly productive firms;
- Capital wedge is relatively small for large, unproductive firms;

- Misallocation of labor is temporary for most firms, and dies out relatively quickly;
- Misallocation of capital is more permanent, and the temporary component dies out slowly;
Background

Labor productivity: stylized facts Netherlands

1. Slowdown labor productivity since mid 1990s in much of the Western world;
2. Slowdown in growth of total factor productivity key contributor (& stagnant capital deepening);
3. Mostly caused by within-sector deceleration, not by sectoral-composition;
(Some) causes slow growth total factor productivity

- Decline in the rate of technological progress → techno-optimists versus techno-optimists
  e.g. Gordon (2016) and Vijg (2011) versus Mokyr (2002), Brynjolfsson and McAfee (2012, 2013);

- Mismeasurement → intangible assets & ict-goods;

- Technology diffusion had declined → “frontier” and “laggard” firms
  e.g. McGowan et al. (2018), Andrews et al. (2016);

- Inefficiencies in the allocation of capital and labor across firms → misallocation
  e.g. Hsieh and Klenow (2009), Gopinath et al. (2017);
Measurement of misallocation

Intuition

- “Frictions” in labor, product and credit markets hinder reallocation and dampen labor productivity dynamics
  Gopinath et al. (2017)
- Significant aggregate productivity gains from re-allocation of resources from low- to high productivity firms

Hsieh and Klenow model: assumptions

- Firms are heterogeneous in their performance & factor-market distortions they face
- Firms supply heterogeneous good which is priced individually in the market
- Firms produces according to Cobb-Douglas production function
Hsieh and Klenow (2009) framework

Key equations Hsieh and Klenow (2009)

Production function: \( Y_i = TFPQ_i L_i^\alpha K_i^{1-\alpha} \),

Profit maximization: \( \pi_i = (1 - \tau_i^Y) P_i Y_i - wL_i - (1 + \tau_i^K) R K_i \),

Profit maximizing price: \( P_i = \frac{\sigma}{\sigma - 1} MC_i \),

Marginal costs: \( MC_i = \left( \frac{RK_i}{\alpha} \right)^\alpha \left( \frac{wL_i}{1-\alpha} \right)^{1-\alpha} \frac{(1+\tau_i^K)^\alpha}{TFPQ_i(1-\tau_i^Y)} \)

Note

- “Wedges” on output (\( \tau_i^Y \)) and capital (\( \tau_i^K \)) are non-standard elements.
- Firms have constant markups depending linearly & solely on \( \sigma \)
- \( TFPQ_i \uparrow \Rightarrow MC_i \downarrow \Rightarrow P_i \downarrow \Rightarrow Y_i \uparrow \)
- \( \tau_i^Y, \tau_i^K \uparrow \Rightarrow MC_i \uparrow \Rightarrow P_i \uparrow \Rightarrow Y_i \downarrow \)
Hsieh and Klenow (2009) framework

Misallocation measures Hsieh and Klenow (2009) : first order conditions

\[ \frac{P_{is}}{t} \frac{\partial Y}{\partial L} = MRPL_i = (1 - \alpha) \left( \frac{\sigma - 1}{\sigma} \right) \left( \frac{P_i Y_i}{L_i} \right) = \left( \frac{1}{1 - \tau_i^Y} \right) w, \]

\[ \frac{P_{is}}{t} \frac{\partial Y}{\partial K} = MRPK_i = \alpha_s \left( \frac{\sigma - 1}{\sigma} \right) \left( \frac{P_i Y_i}{K_i} \right) = \left( \frac{1 + \tau_i^K}{1 - \tau_i^Y} \right) R, \]

\[ TFPR_i = P_i TFPQ_i \propto (MRPL_i)^{1-\alpha} (MRPK_i) \propto \frac{(1 + \tau_i^K)^\alpha}{(1 - \tau_i^Y)} \]

Note:

- In the absence of distortions \( MRPK_i \) & \( MRPL_i \) would be equated across all firms;
- If \( \text{std}(MRPK) \neq 0 | \text{std}(MRPL) \neq 0 \Rightarrow \text{std}(TFPR) \neq 0; \)
- \( \text{Std}(MRPK), \text{std}(MRPL), \tau_i^K \) and \( \tau_i^Y \) our measures of misallocation;

Effect of a change in $TFPQ$

- All “wedges” are zero
- firms with higher $TFPQ_i$ produce more at lower price ($p'^*$)
- Consequence: economy wide $TFPQ$ is at efficient level ($TFPQ_{efficient}$)

Effect of a wedge on capital ($\tau^K$)

- $\tau^K$ is disturbing allocation, $TFPR^* \neq TFPR^*$ $\Rightarrow$ std($TFPR$) $\neq 0$
- Reason: $p^*$ is too high and $y^*$ is too low given firm’s $TFPQ$
- Consequence: economy wide $TFPQ$ is lower than $TFPQ_{efficient}$

$\tau^K$ is disturbing allocation, $TFPR^* \neq TFPR^*$ $\Rightarrow$ std($TFPR$) $\neq 0$
Reason: $p^*$ is too high and $y^*$ is too low given firm’s $TFPQ$
Consequence: economy wide $TFPQ$ is lower than $TFPQ_{efficient}$
Database

**Tax-data from Statistics Netherlands (CBS)**

- Population of Dutch firms that declare corporate income tax in period 2001–2017;
- Matched with firm-level data of Dutch business registry;
- Fine grained industrial division: NACE 5-digit
  - 2-digit: retail trade (47); 5-digit e.g.: Retail sale of fruit and vegetables, (4721), Retail sale of books (4761)
  - 2-digit: civil engineering (42); 5-digit e.g: Construction of roads and motorways (4210), Construction of utility projects for electricity and telecommunications (4250)
  - 93/240 industries in manufacturing/services sector;
- Number of employees, size-class, balance sheet items, profit & loss account.

**Analyzed database**

- Repeated cross-section (highly unbalanced), restricted to non-agricultural non-financial sector;
- “Standard” cleaning (e.g. Gamberoni et al., 2016 and Gopinath et al., 2017);
- Number of firm-year observations: 1,831,575 || firms: 342,245 || 110 thousand p/y;
First look: standard deviation MRPK & MRPL

Increase $\text{std}(\text{MRPK}) >> \text{std}(\text{MRPL})$

![Graph showing the comparison of standard deviations between MRPK and MRPL over the years 2001 to 2017. The graph indicates an increase in the standard deviation of MRPK compared to MRPL.](image-url)
First look: total factor productivity loss

Total TFP Loss

\[ 100 \left( \frac{\text{TFPQ}_{\text{efficient}}}{\text{TFPQ}} - 1 \right) \]

\[ \Rightarrow \text{std}(\text{MRPK}) = \text{std}(\text{MRPL}) = \text{std}(\text{TFPR}) = 0 \]

(From Jasper de Winter, Measuring trends and persistence misallocation)
Misallocation per firm-characteristic

Manufacturing versus services sector
e.g. Dias et al. (2016), Buso et al. (2013), de Vries (2014);
- Capital & labor distortions services sector $\gg$ manufacturing sector;
- Caused by lower competition, limited trade-ability, high regulatory barriers.

Large versus micro firms
e.g. Gopinath et al. (2017), Calligaris et al. (2017);
- Capital & labor distortions large firms $\ll$ small
- Convergence between capital & labor distortions large firms $\rightarrow$ small firms;
- Large firms tend to be older & can self-finance. Less exposed to financial constraints.
Nature of misallocation: ordered probit

**Multivariate ordered probit**

\[ p_{ij} = Pr(y_i = i) = (\kappa_{i-1} < x_j \beta + \mu \leq \kappa_i) \]
\[ = \Phi(\kappa_i - x_j \beta) - \Phi(\kappa_{i-1} - x_j \beta) \]

where, \( \Phi(.) \) is the standard normal cumulative distribution function.

**Dependent variables**

- Deciles of \( \tau_{is,t}^K \) and \( \tau_{is,t}^L \) distribution, the absolute levels of capital and labor;
- Rewritten versions of \( \tau_{is,t}^K \) and \( \tau_{is,t}^Y \) (Hsieh and Klenow, 2009), assuming:
  - \( 1 - \tau_{is,t}^Y = 1/(1 + \tau_{is,t}^L* ) \)
  - \( 1 + \tau_{is,t}^K = (1 + \tau_{is,t}^K*)/(1 + \tau_{is,t}^L*) \).
- Decile 1-2 “very low”, 3-4 “low”, 5-6 “average”, 7-8 “high”, 9-10 “very high”
- Regressors: firm-characteristics, year and **firm’s position in the productivity distribution**: “laggards” (1st), “average” (2nd – 9th), “frontier” (10th)
Nature of misallocation: capital distortion

**Ordered probit** $\tau_i^K$

**Regressors:** dummyset TFPQ (frontier/average/laggard), dummyset size-class (micro, small, medium, large), dummyset year (2001–2017), dummyset NACE Rev.2 (2-digit)

![Diagram](image)
Nature of misallocation: labor distortion

**Ordered probit** $\tau_i^L$

**Regressors:** dummyset TFPQ (frontier/average/laggard), dummyset size-class (micro, small, medium, large), dummyset year (2001–2017), dummyset NACE Rev.2 (2-digit)
Nature of misallocation: capital distortions

Ordered probit $\tau_i^K$ with interactions dummies

**Regressors:** dummyset of TFPQ (frontier/average/laggard) $\times$ size-class (micro, small, medium, large) $\times$ year (2001–2017) and dummyset NACE Rev.2 (2-digit)

<table>
<thead>
<tr>
<th>Micro</th>
<th>Small</th>
<th>Medium &amp; Large</th>
<th>2001</th>
<th>2005</th>
<th>2009</th>
<th>2013</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>Average</td>
<td>Very High</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Laggards</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Frontier</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Nature of misallocation: labor distortions

**Ordered probit $\tau_i^L$ with interactions dummies**

**Regressors:** dummyset of TFPQ (frontier/average/laggard) $\times$ size-class (micro, small, medium, large) $\times$ year (2001–2017) and dummyset NACE Rev.2 (2-digit)

<table>
<thead>
<tr>
<th></th>
<th>'01</th>
<th>'05</th>
<th>'09</th>
<th>'13</th>
<th>'17</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>micro</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>small</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>medium &amp; large</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>very low</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>very high</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>average</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**A. Laggards**

**B. Average**

**C. Frontier**
Persistence of misallocation: permanent and transitory components

How persistent is misallocation?

- Exploit empirical specifications from literature on individual earnings (Ng, 2008; Guvenen, 2009, Doris et al., 2013)
- Split $MRPK/MRPL (y_{i,t})$ in permanent ($y_{i,t}^P$) and transitory ($y_{i,t}^T$) component.

Formula’s Doris et al., 2013

\[
y_{i,t} = y_{i,t}^P + y_{i,t}^T
\]

\[
y_{i,t}^P = p_t \eta_i + \lambda_t v_{i,t}
\]

\[
v_{i,t} = \rho v_{i,t-1} + \varepsilon_{i,t}
\]

\[
V_{t,\infty} = p_t^2 \sigma_\eta^2 + \lambda_t^2 \sigma_{v_1}^2, \quad t = 1,
\]

\[
V_{t,\infty} = p_t^2 \sigma_\eta^2 + \lambda_t^2 (\rho^2 t^{-2} \sigma_{v_1}^2 + \sigma_\varepsilon^2 \sum_{w=0}^{t-2} \rho^{2w}), \quad t > 1.
\]

Doris et al., 2013 intuition

- General Method of Moments (GMM) estimator;
- Firm-level heterogeneity in permanent component (“fixed effect”);
- Transitory component is a homogeneous AR(1) process.
Persistence of misallocation: permanent and transitory components

Permanent & transitory component MRPK and MRPL

- MRPK has become more permanent;
- MRPL has remained mostly transitory;
- **Model fit**: Monte Carlo simulation able to reproduce observed trends
Persistence capital distortions per firm-characteristic

Manufacturing versus services sector

- Permanent component in both manufacturing & services has risen;
- Since ‘09 permanent component ≫ temporary component;
- Difference permanent–transitory has risen most in services sector.

Large firms versus micro firms

- Negative relation firm-size – capital distortions caused by diff. in permanent component;
- Small firms have more permanent distortions than large firms.

Laggards versus frontier firms

- Permanent component increased for all productivity categories;
- Frontier firms have most permanent distortions. Implies high wedges have become more permanent.
productivity loss: mismeasurement of misallocation?

Not all distortions are misallocation...  

<table>
<thead>
<tr>
<th>Distortion</th>
<th>% less misallocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital adjustment costs</td>
<td>5</td>
</tr>
<tr>
<td><strong>Alternative functional form</strong></td>
<td></td>
</tr>
<tr>
<td>Firm-level production function</td>
<td>1</td>
</tr>
<tr>
<td>“CES” versus “CD”</td>
<td>0*</td>
</tr>
<tr>
<td>Heterogeneous markups</td>
<td>25</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>31</strong></td>
</tr>
</tbody>
</table>

* assuming that technology has same impact on all firms (see e.g. Acemoglu and Restrepo, 2017)
Summing up

Main take-aways from our study

- Misallocation of capital in the Netherlands has increased over the period 2001–2017;
- Misallocation of labor has remained more or less stable in our sample;

- Capital wedge is relatively large for small, highly productive firms;
- Capital wedge is relatively small for large, unproductive firms;

- Misallocation of labor is temporary for most firms, and dies out relatively quickly;
- Misallocation of capital is more permanent, and the temporary component dies out slowly;
Future work

Ideas

- Methodology could be applied to other countries as well
- Look more at interaction between balance sheet strength and misallocation (zombie-firms);
- Expand model permanent and transitory component