2020 봄학기 학술 세미나

The RIFI Seminar

: Spring Semester 2020

일시 | 2020. 06. 25 (목) 15:00~17:30

장소 | 단국대학교 죽전캠퍼스 상경관 303호

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RIFI 단국대학교 부설 미래산업연구소
The Research Institute of Future Industry

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2. Liquidity provision of high frequency traders in stressful states

: evidence from the KOSPI 200 futures market - 강한길 교수 (단국대)

3. 항공기 운항시간제한(커퓨)과 항공편 스케줄 차별화

: 국내선과 국제선 비교를 중심으로 - 선주연 교수 (단국대)

4. 글로벌 경제하에서의 테크놀로지, 스킬, 그리고 성장 - 정재원 교수 (단국대)

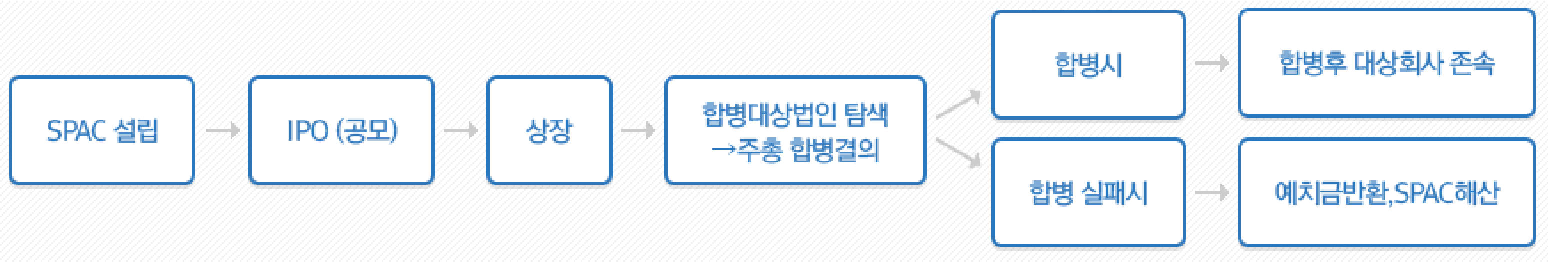
스팩합병 코스닥상장 기업의 재무성과

2020. 06. 25.

가톨릭대학교 박영규

SPAC

- SPAC (Special Purpose Acquisition Company), 출처: 한국거래소
  - 공모(IPO)를 통해 조달한 자금을 바탕으로 다른 기업과 합병하는 것을 유일한 목적으로 하는 명목회사 (Paper Company)
  - 2008년의 글로벌 금융위기로 국내 기업공개 시장 침체→ 신속한 상장기회를 제공을 위해 정부가 2010년 국내 도입
- SPAC의 기본구조



- SPAC의 주주 이익실현
  - 합병성공
    - 합병 후 장기보유를 통해 기업 가치 상승에 따른 투자차익
    - 주식매수청구권을 행사하여 투자이익 실현
  - 합병실패
    - 예치금과 이자수익

우회상장

- 우회상장(Backdoor listing)
  - 비상장기업이 상장기업의 경영권을 인수함으로써 상장기업의 지위를 획득
  - 일부 비상장기업들은 상대적으로 신속하고 용이하게 상장지위를 획득의 수단으로 사용
  - 비상장기업 + 상장기업(표적기업) → 비상장기업의 상장지위획득

- 기존 우회상장의 문제점
  - 우회상장기업이 불공정행위에 연루되거나 조기에 부실화되어 선량한 투자자에게 피해를 끼치는 사례
  - 네오세미테크 사례
    - 코스닥 상장기업 모노솔라와의 합병으로 우회상장
    - 2009년 10월 6일 우회상장 → 분식회계 등을 이유로 감사의견거절 → 2010년 8월 23일 상장폐지 확정

우회상장

- 선행연구
  - 우회상장기업의 특성
    - 수익성이 낮은 기업일수록 우회상장을 선택 (김종일, 이장순, 2009; 최운열, 이호선, 2006; Adjei et al., 2008; Gleason et al., 2008)
    - 낮은 수익성외에도 부채비율이 높고(김종일, 이장순; 2009, Gleason, Jain, Rosenthal, 2008), 기업규모가 작은 기업이 선택(최운열, 이호선, 2006; Adjei, Cyree, Walker, 2008)
    - → 기업규모가 작고 수익성과 재무구조가 열악한 기업이 우회상장을 선택하여 주식시장에 진입
  - 우회상장이후의 성과
    - 상장이후 일반상장기업에 비해 재무성과가 악화(강원, 2010; 윤여준, 강문현, 2009)
    - 일반상장기업에 비해 부실화 및 상장폐지로 이어지는 기업이 높은 극단적인 결과 (김준석, 박영규, 이석훈, 2014; Gleason, Rosenthal, Wiggins III, 2005).

Previous Studies

- 국내
  - 법 연구
    - 초기 법과 제도적인 연구 수행
      - 김범준(2010), 김애경(2008), 김한준(2010), 오영표(2010).
  - 재무/회계 연구
    - 이호선(2014)
      - 2009년부터 2011년까지 상장된 22개의 SPAC분석
      - 공모성과와 합병 전후 주가 분석
    - 이우백(2017)
      - 2010~2015년 상장 SPAC의 합병성과 분석
      - 합병공시~합병기일 지속적인 주가상승
    - 민정기, 차승민(2017)
      - 스팩합병 상장기업의 이익조정 분석
      - 34개의 스팩합병상장기업의 과도한 이익상향조정현상

Previous Studies

- 해외
  - Cumming et al.(2012)
    - SPAC의 합병 승인에 영향을 미치는 요인들을 규명
  - Milan and Milos(2013)
    - 2003년부터 2010년까지 SPAC을 대상으로 합병에 영향을 미친 결정요인을 분석
  - Tran(2012)
    - SPAC의 합병 공시 후 1개월간 1.7%의 수익률 보고
  - Ignatyeva et al.(2013)
    - 유럽시장 분석
    - 합병 공시 후 2.5%의 수익률 보고
    - Datar et al.(2012)
      - SPAC과 합병기업들의 영업성과는 동종 산업 및 IPO 기업들에 비해 낮은 성과
      - 비상장기업의 부채의존도가 높고 소기업일수록, IPO 상장한 기업들에 비해 투자 수준과 성장 기회가 낮음

Research Idea

- 우회상장
  - 인수기업 비상장기업
    - 합병추진 주체가 비상장기업
  - 부실화된 사례 다수 발견
  - 부실한 비상장기업의 상장수단으로 사용가능

- 스팩합병 상장
  - 인수기업 상장기업
    - 합병추진이 스팩의 경영진과 주주
  - 기존 우회상장에 비해 부실화 될 동기가 낮음
  - 해외연구에 의하면 스팩합병 상장기업이 일반상장기업에 비해 영업성과가 열등

- 과연 스팩합병상장기업의 재무성과가 일반상장기업에 비해 열등할 것인가?

Sample

- 표본
  - 표본기간
    - 2011년 ~ 2017년 스팩합병 코스닥상장기업
  - 표본선정
    - 주가 및 재무정보가 존재하는 기업
  - 최종분석 57개 스팩합병 코스닥상장기업

- 비상장기업 특성
  - 코넥스 상장법인 5개
  - 상장폐지 1건

- 통제기업
  - 동일기간 코스닥시장 일반상장기업
  - 최종분석 280개 일반상장기업

Sample

- Sample distribution

	Sample		Control	
	빈도	백분율	빈도	백분율
2011	2	3.51	53	18.93
2012	4	7.02	21	7.5
2013	4	7.02	31	11.07
2014	1	1.75	38	13.57
2015	13	22.81	44	15.71
2016	12	21.05	44	15.71
2017	21	36.84	49	17.5
Sum	57	100	280	100

- SPAC의 합병소요시간

상장일	합병공시일	합병기일	n	mean	median
상장일	합병공시일		57	409.9649	378.0000
	합병공시일	합병기일	57	167.3509	158.0000
상장일		합병기일	57	577.3158	547.0000

Variables

- 재무변수
  - 기초통계량에서 기술
- 주가성과
  - 표본
    - 합병기일 기준
      - (+1M~+12M), (+1M~+24M), (+1M~+36M)
    - BHAR
      - 표본의 BHR – 코스닥지수 BHR
  - 통제기업
    - 상장일 기준
      - (+1M~+12M), (+1M~+24M), (+1M~+36M)

Variables

- 영업성과
  - 표본
    - 합병기일 기준
      - 전년도 기준으로 성과변화 측정
        - dROA(-1,+1), dROA(-1,+2)
      - 당해연도 기준으로 성과변화 측정
        - dROA(0,+1), dROA(0,+2)

  - 통제기업
    - 상장일 기준
      - 전년도 기준으로 성과변화 측정
        - dROA(-1,+1), dROA(-1,+2)
      - 당해연도 기준으로 성과변화 측정
        - dROA(0,+1), dROA(0,+2)

Descriptive Statistics

- 표본과 통제기업의 재무특성

		n	men	medin	n	men	medin	t-stat.	z-stat.
SIZE	LN(자산)	57	17.2405	17.0931	280	17.7473	17.6414	-4.15***	-4.14***
LEV	부채/자산	57	0.4239	0.4000	280	0.4633	0.4669	-1.40	-1.40
ROA	당기순이익/자산	57	0.1601	0.1111	280	0.1502	0.1303	0.49	-0.58
TATOV	총자산회전율	57	1.1148	1.0650	280	1.1429	1.0363	-0.38	-0.34
CR	유동자산/유동부채	57	2.9666	2.4330	280	2.5210	1.7673	1.03	1.98**
CASH_TA	현금및현금성자산/자산	57	0.1938	0.1220	280	0.1491	0.1185	1.74*	1.03
PPE_TA	유형자산/자산	57	0.2123	0.1589	280	0.2967	0.2738	-2.86***	-3.01***
SGA_TA	판매및관리비/자산	57	0.3153	0.2162	280	0.2070	0.1391	2.81***	3.79***

- 일반상장기업과의 비교
  - 규모가 작고, 유형자산 비중이 낮고, 판매 및 관리비 비중이 높음

Sample vs. Control

- 스팩합병기업과 일반상장기업의 특성비교

VARIABLES	(1) group	(2) group	(3) group	(4) group
size	-1.026***	-0.833***	-1.061***	-0.912***
	(-3.403)	(-2.836)	(-3.648)	(-3.156)
lev	-0.433	-0.285	-0.568	-0.481
	(-0.384)	(-0.251)	(-0.486)	(-0.411)
roa	-1.485	-2.213	-1.238	-1.649
	(-0.642)	(-0.878)	(-0.574)	(-0.726)
tatov	-0.262	-0.445	-0.283	-0.489
	(-0.670)	(-1.100)	(-0.671)	(-1.103)
cr	-0.042	-0.072	-0.043	-0.064
	(-0.776)	(-1.065)	(-0.821)	(-0.985)
cash_ta		0.590		-0.104
		(0.518)		(-0.085)
ppe_ta		-1.034		-0.655
		(-1.095)		(-0.666)
sga_ta		1.026		1.202
		(1.621)		(1.493)
Constant	17.161***	14.038***	16.046***	13.666***
	(3.135)	(2.631)	(3.040)	(2.608)
Year Dummy	No	No	Yes	Yes
Observations	337	337	337	337
Chi-squared	12.08	16.61	32.88	33.16

재무성과

- 표본과 통제기업의 재무성과

		n	mean	median	n	mean	median	t-stat.	z-stat.
BHAR	(+1M,+12M)	57	6.5828	-11.2507	280	2.1115	-14.1477**	0.38	0.11
	(+1M,+24M)	57	3.9416	-10.0949	280	-6.2706	-24.4947**	1.00	0.96
	(+1M,+36M)	36	-22.6712**	-35.3052**	230	-8.1809	-34.2814**	-1.18	-0.29
ROA	(-1,+1)	57	-0.1441***	-0.0950***	280	-0.1109***	-0.0859***	-1.06	0.07
	(-1,+2)	36	-0.2325***	-0.1616***	231	-0.1587***	-0.1133***	-1.43	-1.37
	(0,+1)	57	0.0674***	0.0431***	280	-0.0470***	-0.0295***	5.89***	6.32***
	(0,+2)	36	0.0029	0.0139	231	-0.0960***	-0.0550***	3.58***	3.77***

- 주가성과
  - 일반상장기업과 유의적인 차이가 없음
- 영업성과
  - 합병기일 기준 영업성과 변화가 일반상장기업보다 우수함

재무성과

- Dependent variable = dROA(0,+1)

VARIABLES	(1) dROA(0,+1)	(2) dROA(0,+1)	(3) dROA(0,+1)	(4) dROA(0,+1)
group	0.112***	0.108***	0.107***	0.105***
	(6.19)	(6.15)	(5.85)	(5.82)
size	-0.001	0.002	-0.001	0.002
	(-0.11)	(0.44)	(-0.26)	(0.27)
lev	-0.130***	-0.126***	-0.126***	-0.122***
	(-3.64)	(-3.46)	(-3.36)	(-3.21)
roa	-0.248***	-0.270***	-0.247***	-0.266***
	(-3.68)	(-4.30)	(-3.69)	(-4.28)
tatov	-0.007	-0.011	-0.007	-0.011
	(-0.74)	(-1.11)	(-0.74)	(-1.04)
cr	-0.002	-0.003**	-0.002	-0.003**
	(-1.57)	(-2.09)	(-1.53)	(-2.02)
cash_ta		0.031		0.029
		(0.78)		(0.71)
ppe_ta		-0.033		-0.029
		(-1.31)		(-1.17)
sga_ta		0.019		0.016
		(0.88)		(0.73)
Constant	0.075	0.029	0.083	0.040
	(0.75)	(0.27)	(0.85)	(0.38)
Observations	337	337	337	337
R-squared	0.260	0.269	0.269	0.276
Adjusted R-squared	0.247	0.249	0.242	0.242
F-stat	11.81	8.326	7.137	5.872

재무성과

- Dependent variable = BHAR(+1M,+24M)

	(1)	(2)	(3)	(4)
group	6.434	5.998	6.050	5.997
	(0.58)	(0.56)	(0.54)	(0.54)
size	-8.451**	-8.180*	-8.531**	-8.172**
	(-2.22)	(-1.95)	(-2.31)	(-1.97)
lev	-12.988	-11.234	-18.914	-17.299
	(-0.49)	(-0.42)	(-0.73)	(-0.65)
roa	-13.594	-17.956	-16.547	-20.280
	(-0.30)	(-0.42)	(-0.36)	(-0.47)
tatov	-14.644*	-14.007	-14.557*	-13.984
	(-1.67)	(-1.42)	(-1.71)	(-1.48)
cr	-2.905**	-3.147**	-2.914**	-3.160**
	(-2.51)	(-2.27)	(-2.28)	(-2.10)
cash_ta		19.752		17.679
		(0.59)		(0.55)
ppe_ta		-7.569		-8.915
		(-0.28)		(-0.32)
sga_ta		-6.548		-7.079
		(-0.36)		(-0.40)
Constant	175.837**	171.409**	177.008***	172.353**
	(2.57)	(2.35)	(2.61)	(2.39)
Year Dummy	No	No	Yes	Yes
Observations	337	337	337	337
R-squared	0.025	0.026	0.063	0.065
Adjusted R-squared	0.00678	-0.000336	0.0284	0.0212
F-stat	2.194	1.517	2.705	2.100

Conclusions

- 실증결과
  - 스팩합병상장 VS 일반상장
    - 기업규모가 작은 비상장기업이 스팩합병을 통해 코스닥시장에 진입
    - 상장이후 영업성과는 일반상장기업에 비해 우수
  - 스팩합병상장 VS 우회상장
    - 양호한 기업이 스팩합병을 통해 시장에 상장
    - 코스닥시장 진입에 좋은 경로로 활용

Liquidity Provision of High Frequency Traders in Stressful States: Evidence from the KOSPI200 Futures Market

미래산업연구소 학술세미나 (2020 봄)

강한길

Motivation

- High Frequency Traders (HFTs)
  - High speed and sophisticated programs
  - Numerous order submission and cancellation
  - Short inventory cycle
  - Ending the day with a flat position

- Debate on their effect on market quality
  - Pros: Liquidity provision due to high trading volume
  - Cons: Market manipulation, exploiting low frequency traders

  - Kirilenko et al. (2017): The Flash Crash is not from HFTs
  - Brogaard et al. (2018): HFTs supply liquidity in extreme price movements

Summary

- High Frequency Traders' (HFTs) trading activity
  - During stressful states and normal states
  - In the KOSPI200 futures market

- Liquidity provision of HFTs in normal and stressful states
  - Provision: endogenous market maker
  - Demand: information advantage, liquidity-taking

- Foreign HFTs take liquidty
  - In normal states
  - Even more in extreme price movements
  - In advance: information advantage and timing ability

Data

- The KOSPI200 futures market
  - One of the most actively traded equity index futures in the world
  - Fully electronic limit order market
  - No floor traders and designated market makers
- Important features
  - Direct buyer/seller identification
  - Investor group identification (Individual, Institution, Foreigner)
- Data features
  - Intraday transaction-by-transaction data
  - Jan 2010 to June 2014 (1,115 trading days), 9:05 am to 3:00 pm
  - Only front-month futures

Trader categorization

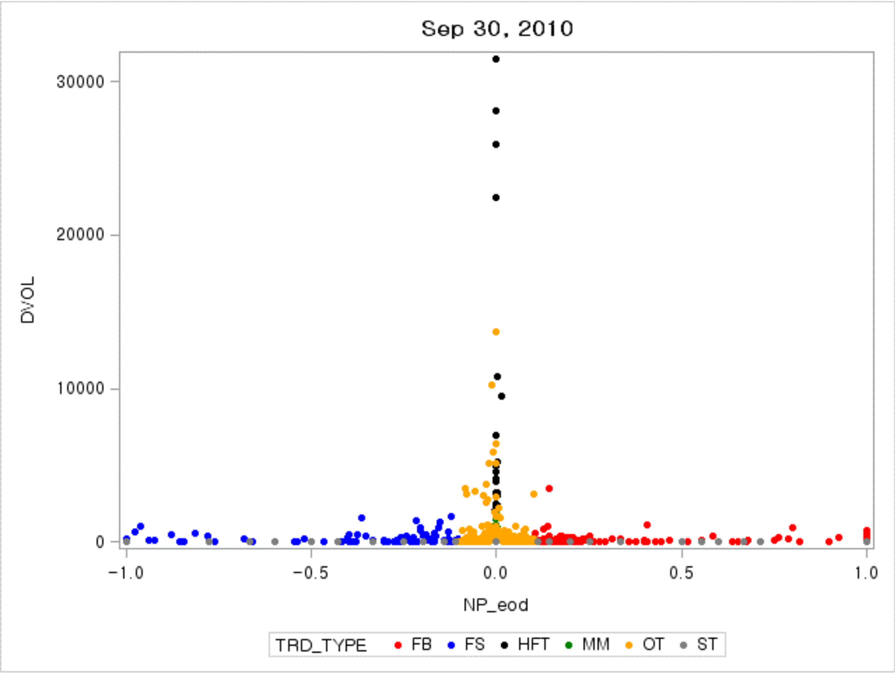
- Intraday intermediary:
  - Trade 10 or more contracts
  - End-of-day net position to its daily trading volume do not exceed 5%.
  - Daily mean of end-of-minute position deviation is almost 0.

- High Frequency Traders (HFTs)
  - 20 most active intraday intermediary accounts
  - in terms of trading volume.

- Market Makers (MMs)
  - Other intraday intermediaries

Trader categorization

- Other accounts:
- Fundamental buyers (FBs)
  - Net end-of-day long position
- Fundamental sellers (FSs)
  - Net end-of-day short position
- Small Traders (STs)
  - Trading volume < 10 contracts
- Opportunistic Traders (OTs)
  - All the remaining accounts



Empirical Methodology
Trader categorization

Table 1. Summary statistics of trader categories

Panel A. Trader type classified by trading behavior

	# Traders	% Dollar Volume	% Share Volume	Trade Size	Order Size	Limit Orders, % Volume	% Aggressiveness
HFT	20	41.39%	41.47%	3.22	50.15	99.71%	51.78%
MM	89	8.13%	8.13%	1.93	5.78	96.74%	40.00%
FB	295	5.42%	5.40%	2.89	23.88	94.74%	49.76%
FS	292	5.46%	5.45%	2.87	23.36	94.93%	49.76%
OT	1,703	37.89%	37.83%	2.27	21.30	94.94%	50.81%
ST	3,053	1.72%	1.71%	1.10	1.18	91.91%	38.10%
	# Traders	Dollar Volume	Share Volume	Trade Size	Order Size	Limit Orders, % Volume	% Aggressiveness
All	5,453	$ 8,367,993,948,006.00	166,328,356	2.56	28.56	97.00%	50.00%

Panel B. Trader type classified by investor identification

	# Traders	% Dollar Volume	% Share Volume	Trade Size	Order Size	Limit Orders, % Volume	% Aggressiveness
FOR	198	29.20%	29.23%	3.01	30.15	98.99%	65.04%
IND	4633	26.45%	26.46%	1.82	12.96	91.52%	42.80%
INS	622	44.35%	44.32%	2.99	42.83	98.96%	44.39%
	# Traders	Dollar Volume	Share Volume	Trade Size	Order Size	Limit Orders, % Volume	% Aggressiveness
All	5,453	$ 8,367,993,948,006.00	166,328,356	2.56	28.56	97.00%	50.00%

Panel C. HFT classified by investor identification

	# Traders	% Dollar Volume	% Share Volume	Trade Size	Order Size	Limit Orders, % Volume	% Aggressiveness
HFT, FOR	6.27	39.01%	38.93%	3.38	41.21	100.00%	67.10%
HFT, IND	1.43	1.22%	1.22%	1.42	2.72	82.95%	41.90%
HFT, INS	12.91	59.77%	59.84%	3.2	57.83	99.86%	42.01%

Empirical Methodology

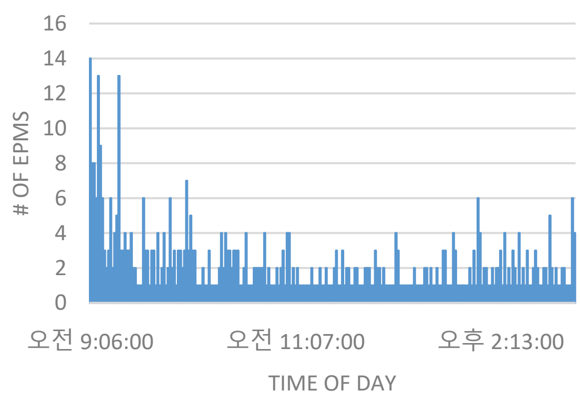
EPM identification

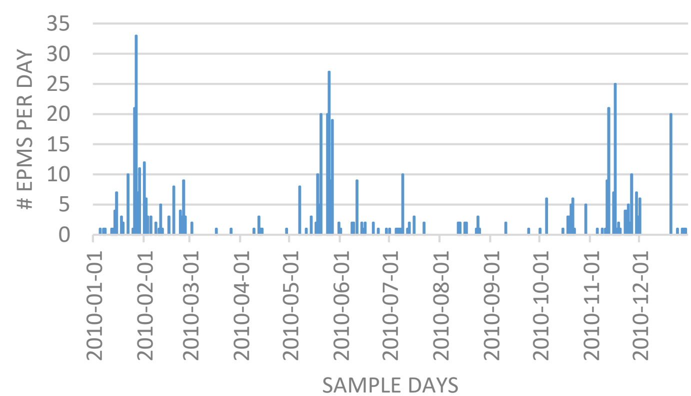
- Stressful states of the market

- Extreme Price Movements (EPMs)
  - 1-second, 10-second intervals
  - 99.9th percentile of absolute midquote return residuals:

$$r_t = \widehat{a_1} r_{t-1} + \cdots + \widehat{a_5} r_{t-5} + e_t$$

- Distribution of EPMs
  - Frequency of EPM is similar except for the case of early morning





Measure of liquidity provision

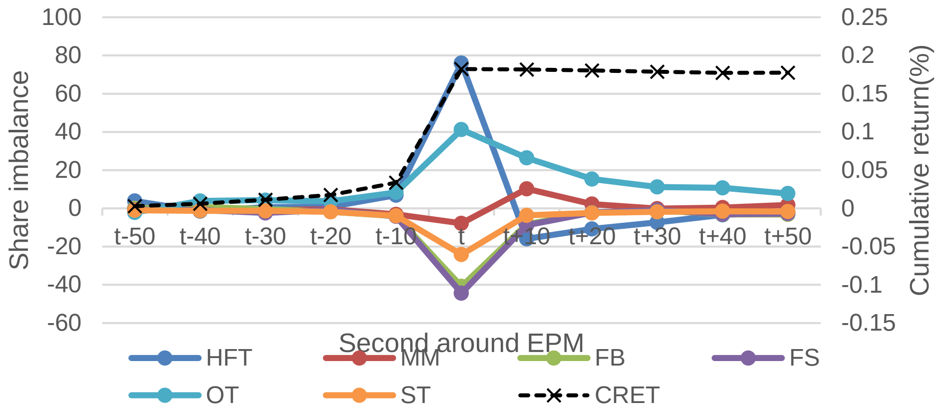
- Directional trade imbalance
  - If one buys (sells) when the price is going up (down), it takes liquidity.
  - If one sells (buys) when the price is going up (down), it provides liquidity.

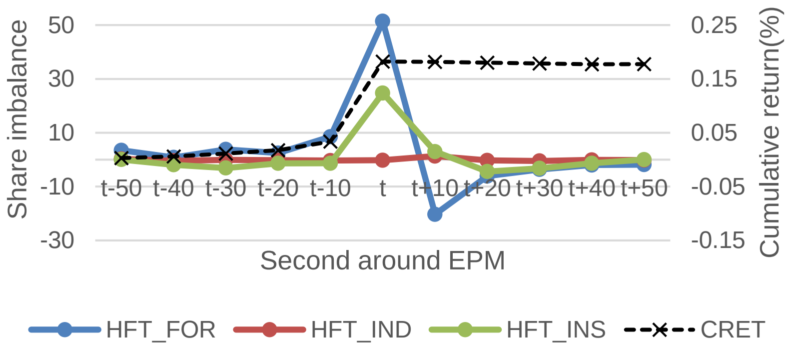
  - Market order: $Type^{M} = Type^{M+} - Type^{M-}$
  - Limit order: $Type^{L} = Type^{L+} - Type^{L-}$
  - Total: $Type^{NET} = Type^{M} + Type^{L}$

  - Positive measure means that the investor group takes liquidity.

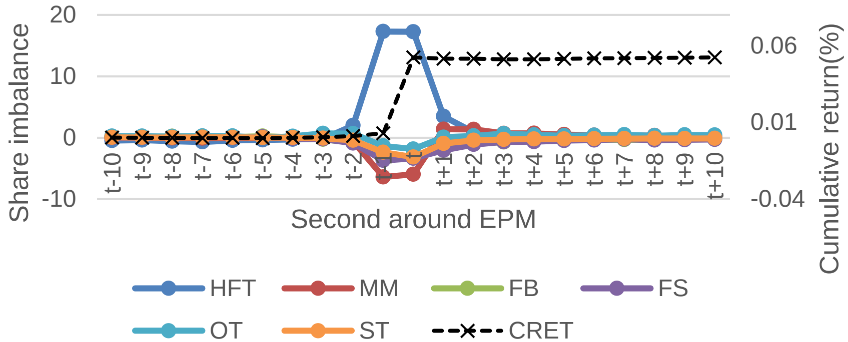
Empirical Results
Liquidity provision around EPMs

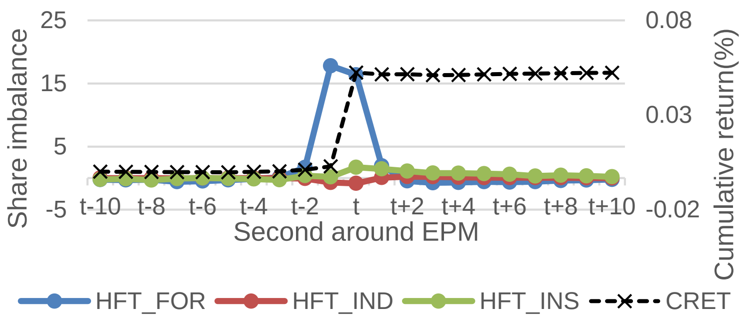
- Liquidity provision of HFTs
  - HFTs do not take liquidity 10 seconds before EPM.





  - They do 1 seconds before EPM.





Sub-analyses

- Regressions: HFT activity on contemporaneous returns
  - Positive coefficient: different from traditional market makers

- Are they profitable?
  - Foreign HFTs are highly profitable.
  - Institutional HFs are less profitable.
  - Individual HFTs lose money.

- Are they more profitable during EPMs?
  - More EPMs → more profitable

Robustness checks

- Subsample period analyses
  - Derivatives market regulation in 2012
  - Many domestic institutions left the market.
  - OTs’ behavior changes to take liquidity.
- Alternative EPM identifications
  - Absolute returns rather than absolute residuals
- Alternative time intervals: 5-sec, 30-sec, 60-sec
  - Results are similar to 10-sec.

Comparison to the literature

- Brogaard et al. (2018)'s results:
  - HFTs provide liquidity during EPMs on single stocks.
  - They were profitable!
  - However, they take liquidity during co-EPMs on multiple stocks.
- In the Korean market:
  - Foreign HFTs take liquidity, and highly profitable.
  - In expense of other HFTs and traditional traders?
- Informational advantage
  - HFTs move before price moves.
  - Especially on market-level movement?
  - Market manipulation?

Policy implications

- Hard to imagine a market without HFTs

- What makes the Korean derivatives market attractive?
  - Very low transaction costs
  - Many individual traders

- To induce HFTs as endogenous market makers
  - To enhance the market quality via their trading activity
  - Incentive design should be related with transaction costs.

- Regulation trends
  - Re-opens the derivatives market to individual traders.
  - Need some investor protection scheme?

Airport curfew and scheduling differentiation: domestic versus international competition

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June 25, 2020

Motivation

1. Before 2008, the international flights from Korea were operated by two full-service carriers—Korean Air (KAL) and Asiana Airlines (AAR).
   - After the entry of LCCs into the international air transport market in 2008, competition intensified on short/medium-haul routes to Asia.

2. As of 2019, LCCs serviced over half of the domestic city-pair market and accounted for 45% of short-haul international passenger traffic.
   - External airport constraints and regulations, such as slot allocation and **night curfews**, affect airline competition and strategic scheduling.
   - To launch new international routes and more frequent flights, LCCs started departing from less congested regional routes, thereby, expanding their bases.
   - The two legacy carriers have developed a carrier-within-carrier (CWC) model.

Main Questions

1. It is of interest to investigate how optimization of domestic/international route structure and flight departures differ according to airport capacity restrictions.

2. Competition is associated with degree of departure flight times differentiation?
   - How this pattern would differ across domestic/international routes departing from regional airports?

3. We examine the effect of easing night curfews on airline flight departure scheduling and find evidence of more differentiated schedules.

Literature Review

1. Hotelling's model of spatial competition (1929)

- With prices set exogenously: less product differentiation results when many different firms control location choices than when a single firm controls all outlets.

2. Applying location theory to airline flight scheduling (**Borenstein and Netz 1999**)

- Departure flight times are differentiated over a time scale (i.e., a day)
- Firms face two opposing incentives: maximize differentiation in order to reduce price competition/minimize differentiation in order to steal customers from competitors.
- Using cross-sectional U.S. airlines' 1975 and 1986 data, they found that airlines schedule their flights more closely to each other's as competition increases.

3. **Yetiskul and Kanafani (2010)** empirically tested the spatial competition model using cross-sectional 2005 U.S. airlines' data. They show that competition intensity leads to less departure time differentiation and confirm that this tendency is lower in the presence of LCCs on a route.

Literature Review

4. **Sun (2015)** presented empirical findings using monthly Korean airline data for 2006–2010 suggesting that competition led to less differentiated departure times and scheduling patterns differ across type of routes—leisure versus business—since deregulation.

5. However, previous studies have examined competition intensity at route level only in domestic markets to estimate its impact on the pattern for scheduling flight departure times.

Contribution to the Literature

1. This study investigates the strategic flight departure scheduling on domestic and short-haul international routes from regional airports in Korea
   - No such studies on the international routes' flight times differentiation
   - A hub-and-spoke system is not the optimal air transport network strategy for the domestic short haul route.
2. This study examines the effects of changes in scheduling constraints induced by airport night curfews on domestic and international routes through competition intensity.
   - The empirical findings suggest that competition leads to less differentiated flight departure times on **domestic** routes from the two regional airports.
   - However, competition leads to more differentiated flight departure times on **international** routes from Daegu airport, which has a **new night curfew**, while a clustered departure pattern is found for international routes from Cheongju airport.
   - An obvious pattern of differentiated departure times is found after the easing of night curfews in 2014, along with the expansion in LCCs.

Low Cost Carriers (LCCs) in Korea

1. Low Cost Carrier

- LCC is an airline business model with low airfare , single passenger class, low operating cost structure, and limited in-flight services

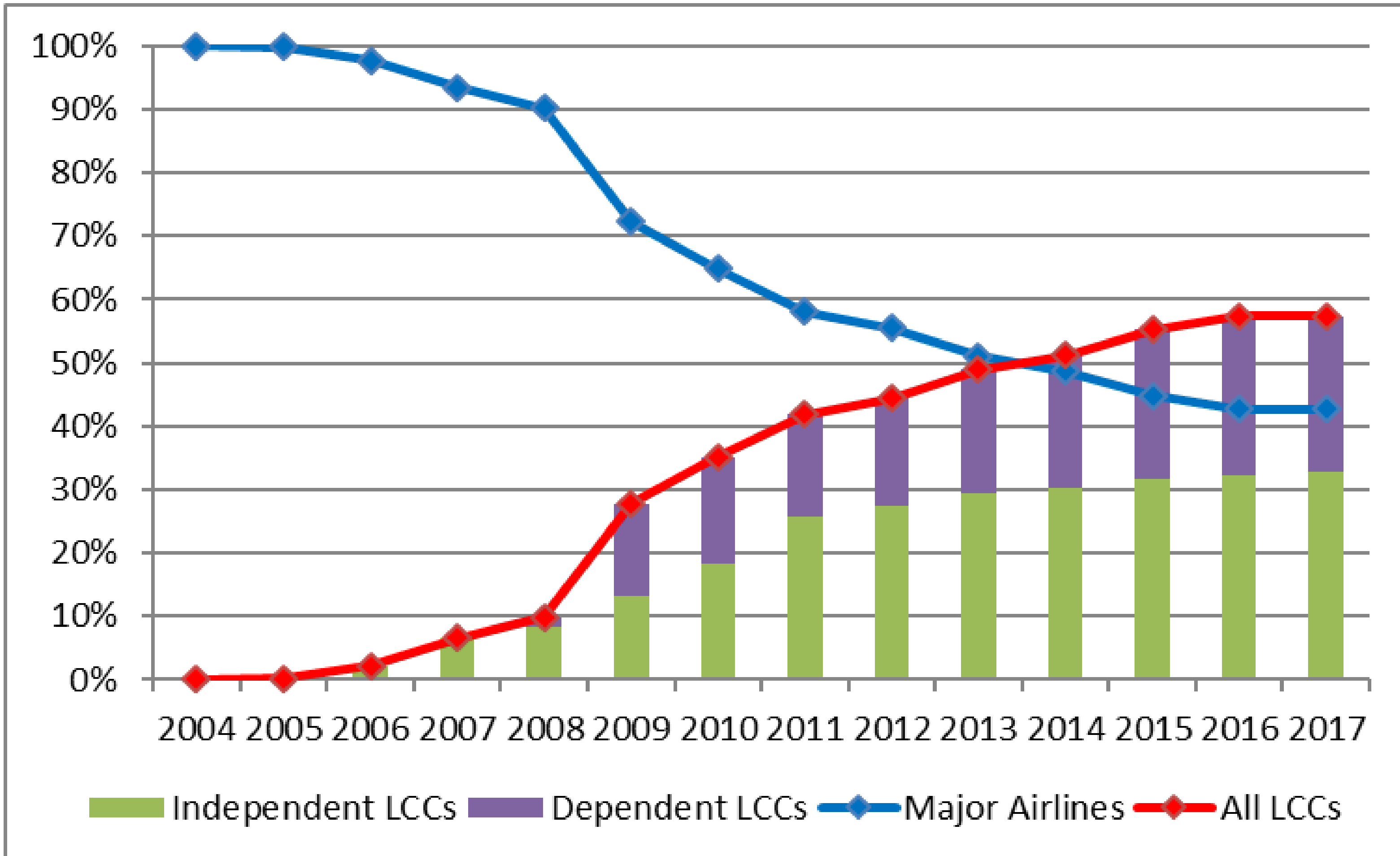
2. Two types of LCCs in Korea from the view point of ownership since 2005

- **Dependent LCC**: Subsidiary LCCs of legacy carriers (full service carriers)
  - Jin Air (JNA) (Korean Air (KAL)'s subsidiary LCC), Air Busan (ABL) (Asiana Air (AAR)'s subsidiary LCC)

- **Independent LCC (Pure LCC)**: NOT owned by legacy carriers
  - Hansung Air (HAN), Jeju Air (JJA), Yeongnam Air (ONA), Eastar Jet (ESR)

Emergence of Competitive Independent LCCs

<Figure. Korean ***domestic*** flight shares operated by **legacy carriers and LCCs**>



Regional airports in Korea

1. There are 15 airports in Korea, of which 8 are international.

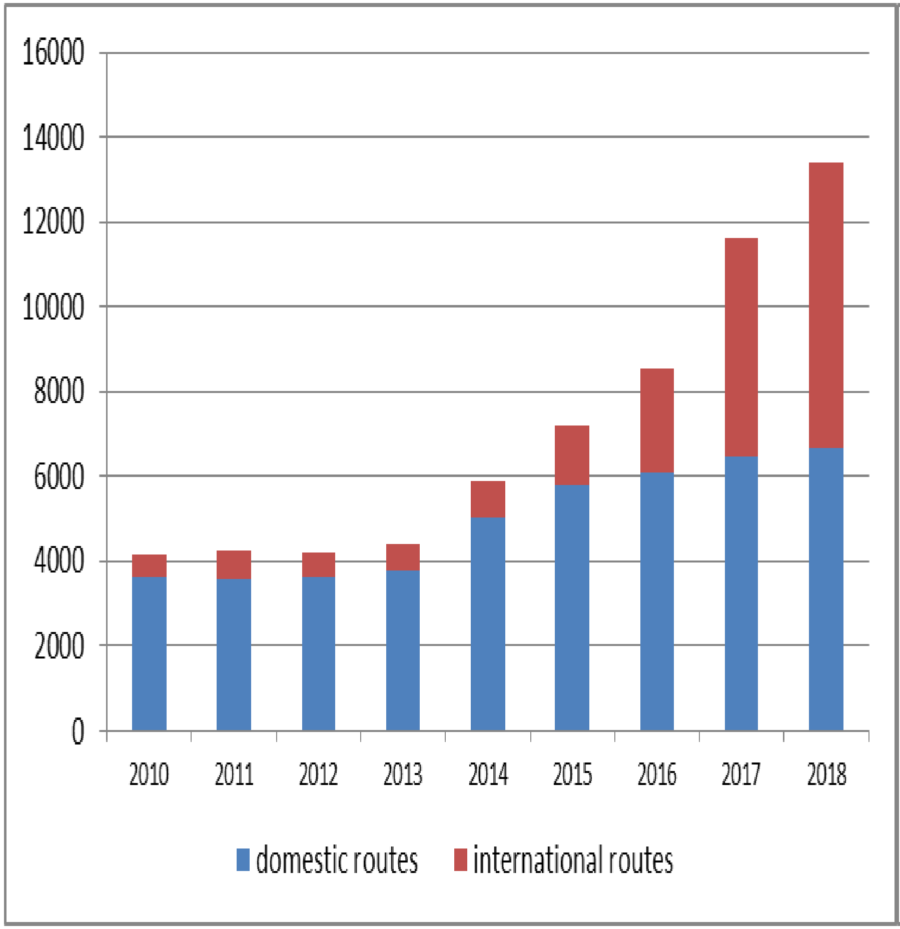
- The airlines departing from the two largest cities, Seoul and Busan or Jeju Island face capacity constraints because of airport traffic congestion. At these airports, there are no additional slot restrictions on international routes available for LCCs.

2. Daegu and Cheongju international airports are not constrained by their utilization of runway capacity during peak demand. LCCs in Korea operate short-haul international flights from these two regional airports, capturing the air travel demand out of the major cities.

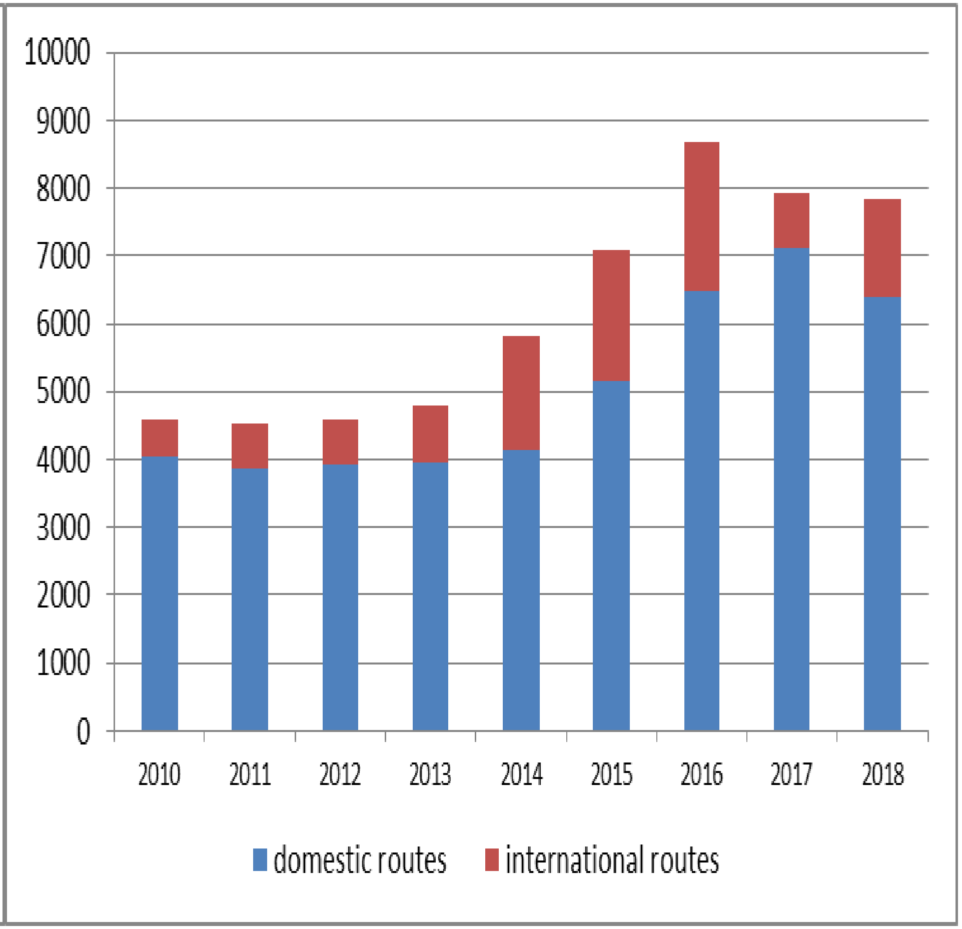
- **Daegu**: Tway Air (TWB) has been expanding its Daegu base.
- **Cheongju**: Eastar Jet (ESR), has been expanding its Cheongju base.
- The two airports in non-major cities pursued different strategies for airport-level international route diversification before and after the THAAD crisis.
- The proportion of international routes to Japan from Daegu was 57.0% in 2017 and 49.9% in 2018, showing a substantial growth compared to 17.2% from 2010 to 2018. Cheongju airport's dependence on international routes to mainland China is significant even after the widespread boycott of Korean products

Domestic and international flight frequency

Daegu International Airport



Cheongju International Airport



Airport-specific night curfews in Korea

1. Most of the international airports in Korea have curfew times, with **Cheongju airport** being one of the few exceptions, as it operates for **24 hours** (Incheon is open 24 hours but is accessible for 2 hours to downtown Seoul. Gimhae, Gimpo, and Jeju operate from 6 am till 23 pm local time.).
2. **Daegu airport** has been subject to a strict curfew time. The night curfew for Daegu airport, from 10 pm to 6 am, was imposed in July 2008. The airport closes at night during the 8-hour curfew. Daegu Airport announced **a new curfew in July 2014** so that its runways were constantly in use from 5am to midnight.
3. The restrictions on airport operating hours were eased **from 8 hours to 5**, which enabled LCCs to launch new international routes from **Daegu**. This easing of night curfew, combined with the LCCs' expanding their Daegu base, has led to a substantial traffic growth at Daegu airport.

Model Specification: Variables

1. Concentration measures: COMPsingle vs COMPmulti

We define a measure for **competition level**, which is equal to **the inverse of the** Herfindahl-Hershman index (**HHI**), ranging from 0 to 1.

- Herfindahl Hirschman Index (HHI) is calculated as the sum squares of flight frequency market shares, $HHI = \sum_{i=1}^{n} s_i^2$ $(i\ is\ ith\ carrier\ id)$.
  - A higher HHI number indicates that the route is less competitive, while a lower HHI number indicates the opposite.
- When aggregating airport-level competition among carriers on domestic routes, we use two carrier-level flight frequency weights according to LCC classification:

  1) weight of domestic flight frequency share of each carrier competing with all other carriers: HHIsingle

  2) weight of domestic flight frequency share of each carrier, but where legacy carriers and their subsidiary LCCs are considered a single entity, not in competition with each other: HHImulti

Model Specification: Variables

2. Measure of overall differentiation: the DIFF index

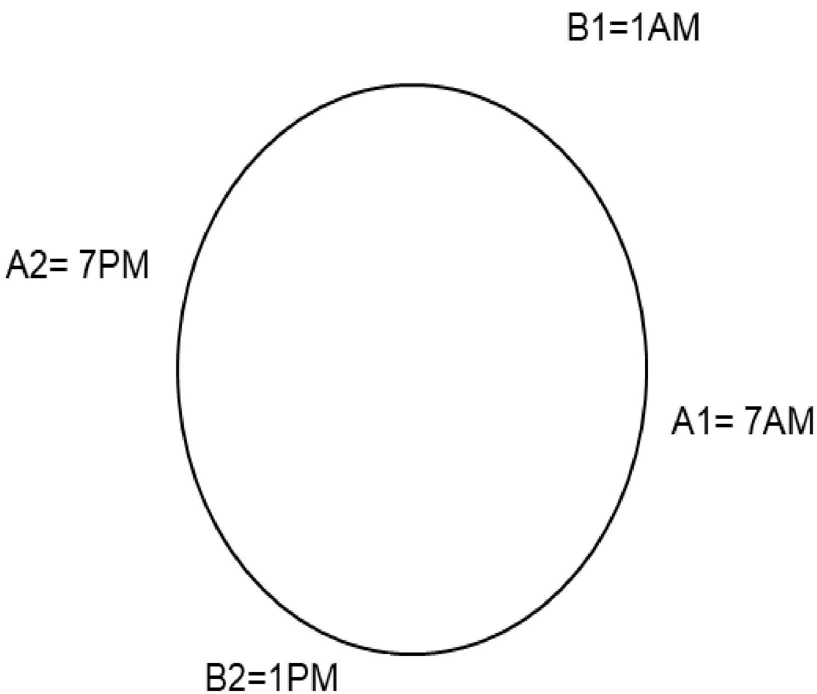
- Followed by Borenstein and Netz (1999), DIFF is used as a measure for ***overall*** flight times differentiation.
- DIFF takes a value in the interval [0,1]. The closer the index to 1, the flights are more evenly distributed over a 24-h clock, maximizing departure time differentiation. When this index is equal to 0, all flights depart at the same time, meaning no differentiation in departure times.

$\mathrm{DIFF} = \frac{AVGDIFF}{MAXDIFF}$ takes a value in the interval [0,1].

$$\mathrm{AVGDIFF} = \frac{2}{n(n-1)} \sum_{i=1}^{n-1} \sum_{j>1}^{n} \left[min\{|d_i - d_j|, 1440 - |d_i - d_j|\}\right]^{\alpha}, 0 < \alpha < 1$$

$$\mathrm{MAXDIFF} = \begin{cases} \frac{2}{n(n-1)} \sum_{k=1}^{n/2-1} n\left(k\frac{1440}{n}\right)^{\alpha} + \frac{n}{2}(720)^{\alpha}, \forall n = even \\ \frac{2}{n(n-1)} \sum_{k=1}^{(n-1)/2} n\left(k\frac{1440}{n}\right)^{\alpha}, \forall n = odd. \end{cases}$$

Example 1: *Maximum* Differentiation, DIFF=1 (n=4)



DIFF=1.000
BtwnDIFF=0.8787

Each carrier A and B schedules one morning flight, and one evening flight, respectively.

Example 1: Construction of Differentiation Measure

Airline	dt	ti	d1	d2	d3	*min*		
B2	1	60	0	0	0	0	0	0
A1	7	420	360	0	0	360	0	0
B1	13	780	720	360	0	720	360	0
A2	19	1140	1080	720	360	360	720	360
Airline	dt	ti	1440-||			*min^a*		
B2	1	60	1440	1440	1440	0	0	0
A1	7	420	1080	1440	1440	18.97366596	0	0
B1	13	780	720	1080	1440	26.83281573	18.97366596	0
A2	19	1140	360	720	1080	18.97367	26.83282	18.97367
						AVGDIFF	MAXDIFF	**DIFF**
						21.5934	21.5934	**1.0000**

Example 2: HHI, DIFF

- DIFF takes a value in the interval [0,1]. The closer the index to 1, the flights are more evenly distributed, maximizing departure time differentiation. When this index is equal to 0, all flights depart at the same time, meaning no differentiation in departure times.

Airline	dt	ti
티웨이항공	6:20	380
티웨이항공	6:50	410
대한항공	6:55	415
에어부산	8:35	515
티웨이항공	9:10	550
아시아나항공	9:20	560
대한항공	9:30	570
티웨이항공	10:05	605
제주항공	11:20	680
대한항공	11:30	690
아시아나항공	12:20	740
제주항공	16:05	965
티웨이항공	16:15	975
대한항공	16:45	1005
에어부산	17:55	1075
대한항공	18:25	1105
아시아나항공	18:55	1135
티웨이항공	19:15	1155
에어부산	20:05	1205

yyyymm	id	fsc	dep.lcc	ind.lcc	flightfreq	HHIsbne	HHImbne
201801	ABL	0	1	0	83	0.2307	0.2777
201801	AAR	1	0	0	91		
201801	KAL	1	0	0	152		
201801	TWB	0	0	1	179		
201801	JJA	0	0	1	62		

AVGDIFF	MAXDIFF	DIFF
16.7463	18.6747	0.8967

Data: Summary Statistics

Table 1. Summary statistics for **domestic** routes (2010–2018)

Domestic routes	Daegu airport (r = 1) with reduction in night curfews				
Variable	Obs	Mean	Std.Dev.	Min	Max
DIFF	108	0.8483	0.0274	0.8062	0.9039
COMPsingle	108	3.0538	1.1373	1.8077	4.6490
HHIsingle	108	0.3784	0.1394	0.2151	0.5532
COMPmulti	108	2.8409	0.8959	1.8077	3.9479
HHImulti	108	0.3913	0.1260	0.2533	0.5532
FlightFreq	108	413	109	254	578
Loadfac	108	0.7681	0.0891	0.5404	0.9305
allLCCshare	108	0.2503	0.2441	0.0000	0.5744
indLCCshare	108	0.2135	0.2044	0.0000	0.4639
Curfew	108	0.5000	0.5023	0	1

Data: Summary Statistics

Table 1. Summary statistics for **domestic** routes (2010–2018)

Domestic routes	Cheongju airport (r = 2) with no curfew				
Variable	Obs	Mean	Std.Dev.	Min	Max
DIFF	108	0.8537	0.0193	0.8118	0.8986
COMPsingle	108	4.1591	0.4941	3.6140	4.9456
HHIsingle	108	0.2436	0.0272	0.2022	0.2767
COMPmulti	108	3.5626	0.3221	2.8273	3.9620
HHImulti	108	0.2832	0.0276	0.2524	0.3537
FlightFreq	108	418	109	282	654
Loadfac	108	0.8212	0.0772	0.5977	0.9472
allLCCshare	108	0.4891	0.1170	0.3516	0.6993
indLCCshare	108	0.3901	0.0378	0.3227	0.5175
Curfew	N/A				

Data: Summary Statistics

Table 2. Summary statistics for **international** routes (2010–2018)

International routes	Daegu airport (r = 1) with reduction in night curfews				
Variable	Obs	Mean	Std.Dev.	Min	Max
DIFF	108	0.6726	0.2400	0.1667	0.9563
COMPsingle	108	3.1464	0.9028	1.5728	5.6625
HHIsingle	108	0.3436	0.0954	0.1766	0.6358
FlightFreq	108	181	196	18	770
Loadfac	108	0.7014	0.0849	0.5095	0.9232
Duration	108	159.3	22.8	110.7	235.7
allLCCshare	108	0.3979	0.3287	0.0000	0.9312
indLCCshare	108	0.3238	0.2304	0.0000	0.6874
Nationalshare	108	0.4142	0.3308	0.0000	0.9312
Curfew	108	0.5000	0.5023	0.0000	1.0000

Data: Summary Statistics

Table 2. Summary statistics for **international** routes (2010–2018)

International routes	Cheongju airport ($r = 2$) with no curfew				
Variable	Obs	Mean	Std.Dev.	Min	Max
DIFF	107	0.7700	0.1155	0.3828	0.9704
COMPsingle	107	3.4147	1.0574	1.6069	6.4226
HHIsingle	107	0.3201	0.0952	0.1557	0.6223
FlightFreq	107	101	65	14	286
Loadfac	107	0.6634	0.0987	0.4517	0.8803
Duration	107	160.3	32.9	124.5	256.7
allLCCshare	107	0.3956	0.1976	0.0000	0.7922
indLCCshare	107	0.3903	0.1953	0.0000	0.7922
Nationalshare	107	0.7455	0.1448	0.4444	1.0000
Curfew	N/A				

Regression Models

I. Domestic routes

Daegu airport (r=1) with reductions of night curfews

$$\mathrm{L}DIFF_t^r = \beta_0^r + \beta_1^r LCOMPsingle_t^r + \beta_2^r LFlightFreq_t^r + \beta_3^r LLoadfac_t^r + \beta_4^r allLCCshare_t^r + \beta_5^r Curfew_t^r + \varepsilon_t, \qquad eq(1a)$$

$$\mathrm{L}DIFF_t^r = \beta_0^r + \beta_1^r LCOMPmulti_t^r + \beta_2^r LFlightFreq_t^r + \beta_3^r LLoadfac_t^r + \beta_4^r indLCCshare_t^r + \beta_5^r Curfew_t^r + \varepsilon_t, \qquad eq(1b)$$

Cheongju airport (r=2) with no curfew

$$\mathrm{L}DIFF_t^r = \beta_0^r + \beta_1^r LCOMPsingle_t^r + \beta_2^r LFlightFreq_t^r + \beta_3^r LLoadfac_t^r + \beta_4^r allLCCshare_t^r + \varepsilon_t, \qquad eq(2a)$$

$$\mathrm{L}DIFF_t^r = \beta_0^r + \beta_1^r LCOMPmulti_t^r + \beta_2^r LFlightFreq_t^r + \beta_3^r LLoadfac_t^r + \beta_4^r indLCCshare_t^r + \varepsilon_t, \qquad eq(2b)$$

Regression Models

II. International routes

Daegu airport (r=1) with reductions of night curfews

$$\mathrm{L}DIFF_t^r = \beta_0^r + \beta_1^r LCOMPsingle_t^r + \beta_2^r LFlightFreq_t^r + \beta_3^r LLoadfac_t^r + \beta_4^r LDuration_t^r + \beta_5^r allLCCshare_t^r + \beta_6^r Curfew_t^r + \varepsilon_t, \quad eq(1c)$$

Cheongju airport (r=2) with no curfew

$$\mathrm{L}DIFF_t^r = \beta_0^r + \beta_1^r LCOMPsingle_t^r + \beta_2^r LFlightFreq_t^r + \beta_3^r LLoadfac_t^r + \beta_4^r LDuration_t^r + \beta_5^r allLCCshare_t^r + \varepsilon_t, \quad eq(2c)$$

Instrumental Variables

- There is clearly an endogeneity issue between passenger **load factor** and the dependent variable, DIFF.
- ***LoadFac*** is correlated to the error term if the error term incorporates cyclical fluctuations.
- A convenient flight schedule during peak demand would lead to higher load factors.
- Scheduling flight departures can be constrained by both demand-side and supply-side factors.
- High demand during peak season and air-fuel costs would affect the number of passengers and available seats and, thereby, the load factor.
- Thus, we control for potentially endogenous variables using IVs. The peak season dummy variable—air-fuel costs—and the number of airlines are used as excluded instruments

Estimation: Expected Signs of Coefficients

Dep.var DIFF	sign	Interpretation of the regression coefficients
COMP $=\frac{1}{HHI}$	**-**	overall **min** differentiation; competition leads to **less** differentiated flight departure times
COMP $=\frac{1}{HHI}$	**+**	overall **max** differentiation; competition leads to **more** differentiated flight departure times

Regression results for domestic routes (2010–2018): Daegu with reductions of night curfews, Dependent variable LDIFF

	Daegu airport (r = 1) with reductions of night curfews			
	(1) OLS	(2) IV	(3) OLS	(4) IV
LCOMPsingle	-0.127* (0.067)	-0.132** (0.065)		
LCOMPmulti			-0.223 (0.157)	-0.269* (0.162)
LFlightFreq	-0.125*** (0.046)	-0.114** (0.045)	0.149*** (0.040)	0.188*** (0.042)
LLoadfac	0.127*** (0.022)	0.0745* (0.039)	0.111*** (0.022)	0.0308 (0.050)
allLCCshare	0.475*** (0.093)	0.487*** (0.090)		
indLCCshare			0.101 (0.218)	0.118 (0.219)
Curfew	-0.0583 (0.041)	-0.0589 (0.043)	0.0346 (0.022)	0.0477* (0.025)
constant	0.661*** (0.250)	0.585** (0.249)	-0.847*** (0.237)	-1.064*** (0.243)
No. observation	108	108	108	108
Instrumented	N/A	LLoadfac	N/A	LLoadfac
adj.R^2	0.464	0.436	0.392	0.331

Robust standard errors are in parentheses
* $p<0.10$, ** $p<0.05$, *** $p<0.01$

Regression results for domestic routes (2010–2018): Cheongju with no curfew, Dependent variable LDIFF

	Cheongju airport ($r = 2$) with no curfew			
	(5) OLS	(6) IV	(7) OLS	(8) IV
LCOMPsingle	-0.184*** (0.050)	-0.182*** (0.059)		
LCOMPmulti			0.349*** (0.125)	0.350** (0.147)
LFlightFreq	-0.00964 (0.036)	-0.00235 (0.032)	0.0860*** (0.028)	0.0841** (0.034)
LLoadfac	0.0904*** (0.025)	0.117*** (0.039)	0.0987*** (0.022)	0.0861** (0.037)
allLCCshare	0.269*** (0.096)	0.256*** (0.096)		
indLCCshare			-0.173 (0.150)	-0.178 (0.161)
Curfew				
constant	0.0646 (0.172)	0.0327 (0.169)	-1.027*** (0.255)	-1.019*** (0.321)
No. observation	108	108	108	108
Instrumented	N/A	LLoadfac	N/A	LLoadfac
adj.R^2	0.314	0.305	0.303	0.301

Robust standard errors are in parentheses
* $p<0.10$, ** $p<0.05$, *** $p<0.01$

Regression results for international routes (2010–2018): Daegu with reductions of night curfews, Dependent variable LDIFF

	Daegu airport (r = 1) with reductions of night curfews					
	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
LCOMPsingle	0.432*** (0.151)	0.391** (0.155)	0.309** (0.131)	0.300** (0.133)	0.368** (0.147)	0.343** (0.153)
LFlightFreq	-0.0292 (0.080)	-0.0996 (0.089)	0.0761 (0.054)	-0.00524 (0.069)	-0.00882 (0.083)	-0.106 (0.091)
LLoadfac	0.451 (0.310)	1.880* (0.970)	0.399 (0.315)	1.615* (0.912)	0.509 (0.308)	2.155** (1.034)
LDuration	0.0362 (0.144)	-0.407 (0.383)	0.129 (0.145)	-0.264 (0.375)	0.0555 (0.149)	-0.463 (0.411)
allLCCshare	0.871*** (0.300)	0.657* (0.347)				
indLCCshare			0.938*** (0.261)	0.746** (0.294)		
Nationalshare					0.778** (0.302)	0.599* (0.352)
Curfew	0.187* (0.110)	0.196* (0.109)	0.137 (0.113)	0.154 (0.109)	0.186 (0.119)	0.187 (0.120)
constant	-1.283 (0.799)	1.933 (2.462)	-2.059** (0.824)	0.812 (2.422)	-1.359* (0.805)	2.418 (2.626)
No. observation	108	108	108	108	108	108
Instrumented	N/A	LLoadfac	N/A	LLoadfac	N/A	LLoadfac
adj.R^2	0.707	0.649	0.716	0.675	0.701	0.623

Robust standard errors are in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Regression results for international routes (2010–2018): Cheongju with no curfew, Dependent variable LDIFF

	Cheongju airport (r = 2) with no curfew					
	(7) OLS	(8) IV	(9) OLS	(10) IV	(11) OLS	(12) IV
LCOMPsingle	-0.193*** (0.069)	-0.170** (0.070)	-0.218*** (0.072)	-0.195*** (0.072)	-0.106* (0.063)	-0.142* (0.075)
LFlightFreq	0.172*** (0.045)	0.171*** (0.045)	0.180*** (0.045)	0.178*** (0.045)	0.137*** (0.040)	0.161*** (0.052)
LLoadfac	0.318*** (0.107)	0.0771 (0.248)	0.325*** (0.107)	0.105 (0.246)	0.249** (0.114)	-0.274 (0.463)
LDuration	0.0821 (0.099)	0.156 (0.106)	0.0894 (0.099)	0.156 (0.105)	0.0314 (0.109)	0.194 (0.161)
allLCCshare	-0.334** (0.149)	-0.299** (0.144)				
indLCCshare			-0.385** (0.151)	-0.351** (0.144)		
Nationalshare					-0.102 (0.146)	-0.303 (0.216)
Curfew						
constant	-0.975* (0.585)	-1.482** (0.654)	-1.003* (0.586)	-1.463** (0.650)	-0.698 (0.603)	-1.656* (0.965)
No. observation	107	107	107	107	107	107
Instrumented	N/A	LLoadfac	N/A	LLoadfac	N/A	LLoadfac
adj.R^2	0.426	0.397	0.438	0.415	0.381	0.258

Robust standard errors are in parentheses
* $p<0.10$, ** $p<0.05$, *** $p<0.01$

Conclusion

- This study examines the effects of changes in scheduling constraints induced by airport night curfews on domestic and international routes through competition intensity.
  - The empirical findings suggest that competition leads to less differentiated flight departure times on domestic routes from the two regional airports.
  - However, competition leads to more differentiated flight departure times on international routes from Daegu airport, which has a new night curfew, while a clustered departure pattern is found for international routes from Cheongju airport.
  - An obvious pattern of differentiated departure times is found after the easing of night curfews in 2014, along with the expansion in LCCs.

Q & A

Korean Airline Deregulation Act of May 2008

- The Deregulation Act of May 2008: implementation and effects

	Before May 2008		After May 2008	
Regulation system	Scheduled air service	Non-scheduled air service	Domestic service	International service
Requirement	License	Registration		
Aircraft size	No limit	80 seats limit per plane	-	-
Aircraft age	No limit	Less than 25 years	-	-

1. Pre-deregulation period:

- Since 2005, a few independent LCCs operated turbo-propeller aircraft with less than 80 seats.

2. Post-deregulation period:

- Removal of restrictions on aircraft size, fleet age, and **flight frequency** for LCCs
  - All LCCs were able to operate larger jet aircraft which had more than 80 seats per airplane, and more frequently.

- Regulation for pricing still remains: Pre-announcement system prior to 20 days.

Technology, Skill, and Growth in a Global Economy

Jaewon Jung

(Dankook University)

Presentation Outline

- Introduction
- The Model
  - Heterogeneous Firms & Workers
  - Technology-Augmented Skill Distribution (TASD)
  - Innovation Sector
  - Equilibrium & Steady-State Growth
- The Effects of Offshoring
  - Basic Mechanism
  - Welfare & Growth Effects
- Numerical Simulation
- Conclusion

Motivation

- Growth economists have considered, among other factors, technology and skill (or human capital) to be at the heart of economic growth:
  $\rightarrow$ The emergence of endogenous growth theory in the mid-1980s.
- Though many important technology-growth and/or skill-growth links have been revealed, the growth theory has paid scant attention to the very interplay between technology and skill, and its implication on growth.
- Labor assignment decisions and the implications on labor productivity have been at the center of concerns in labor economics (Roy, 1951):
  - Workers choose tasks (or occupations) requiring different technologies based on their comparative advantage.
  - Workers' productivity reflects not only their own skill level but also the task/occupation-specific technology they are employing.
- Also, the nature of globalization is changing: trade in tasks and global supply chain (Baldwin, 2006; Grossman and Rossi-Hansberg, 2008).
- Starting point: if technology would exhibit any increasing returns to skill, equilibrium technology-skill matching itself would have considerable implications for economic growth !

This Paper

- Develop an endogenous growth model based on a Roy-like assignment model in which heterogeneous workers endogenously sort into different technologies/tasks according to their comparative advantage.
- Model explicit distinction between worker skills and tasks, incorporating worker skill distribution and task-specific technologies:
  - $\rightarrow$ Endogenous *"Technology-Augmented Skill Distribution (TASD)".*
- Also, incorporate heterogeneous firms:
  - $\rightarrow$ Endogenous firms' technological & offshoring decisions.
- Analyze technology-skill-growth and offshoring-growth links within a unified theoretical general-equilibrium framework.
- The model provides richer predictions (empirically testable) on the relationship between labor market changes and growth, and on the static and dynamic welfare implications for different worker groups on the skill ladder:
  - $\rightarrow$ *"Technology up- and downgrading mechanism"* at both individual worker and firm levels.

Related Literature

- *Endogenous growth literature* (e.g. Romer, 1986, 1990; Lucas, 1988; Aghion and Howitt, 1992):
  - In international trade context (e.g. Rivera-Batiz and Romer, 1991 a,b; Grossman and Helpman, 1991 a,b; Young, 1991):
    - → Overall, pro-growth effects of openness.
  - In North-South context (e.g. Helpman, 1993; Dinopoulos and Segerstrom, 2010; Branstetter and Saggi, 2011):
    - → Importance of intellectual property rights.
- *Assignment and globalization literature* with heterogeneous workers (e.g. Grossman and Maggi, 2000; Grossman, 2004; Yeaple, 2005; Antràs, Garicano and Rossi-Hansberg, 2006; Costinot and Vogel, 2010; Helpman, Itskhoki and Redding, 2010; Blanchard and Willmann, 2013; Jung and Mercenier, 2014):
  - Also, closely related to firm heterogeneity literature in international trade.
  - Labor market effects of globalization by endogenous sorting of heterogeneous workers.

Basic Setup: Households & Firms

- Infinitely lived representative consumer has intertemporal preferences:

$$U = \int_{t=0}^{\infty} e^{-\rho t} \ln C_t dt, \qquad C = \left[\int_{i \in N} x(i)^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}$$

- Continuum of manufacturing firms produce $x(i)$, combining two inputs $h(i)$ and $m(i)$:

$$x(i) = h(i) = m(i)$$

Headquarter services: only in the North

Intermediate components: North & South

- Individual firm's technological and organizational choice:
  - Managerial technology for $h(i)$:
    - $\rightarrow$ 2 technologies H & L: $C_H < C_L$ with $f_H > f_L$.
  - Organizational choice for $m(i)$:
    - $\rightarrow$ Producing domestically or offshoring: $C_M > C_M^*$ with $f_O > 0$.

- Firms sort in equilibrium between two types, and compete under monopolistic competition:
  - Low-tech non-multinationals (*non-MNs*) with f_L $\rightarrow$ $p_L = \frac{\sigma}{\sigma-1}(C_L + C_M)$
  - High-tech multinationals (*MNs*) with $f_H + f_O$ $\rightarrow$ $p_H = \frac{\sigma}{\sigma-1}(C_H + C_M^*)$

Basic Setup: Heterogeneous Workers

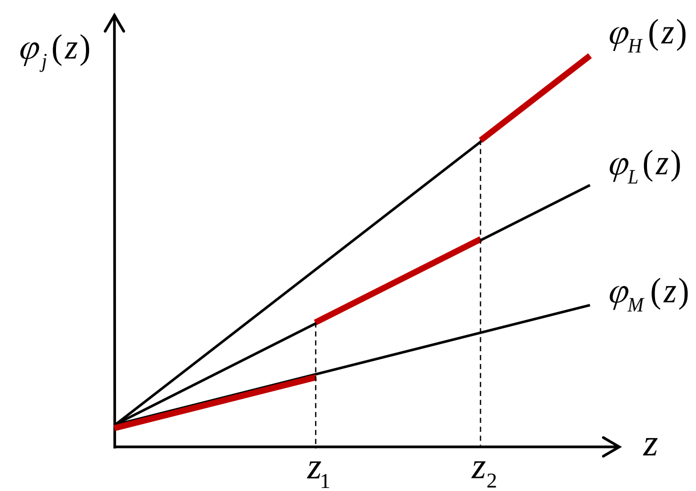
- Continuum of heterogeneous workers differentiated by skill level z:
  - Cumulative skill distribution $G(z)$ with density $g(z)$ on support $(0, \infty)$.
- Worker productivity reflects both his own skill level z and the technology he employs:
  - Let $\varphi_j(z)$ denote the productivity of a worker with skill z and technology $j \in \{M, L, H\}$.

$\rightarrow$ Absolute advantage at given technologies: if $z_1 < z_2$, $\varphi_j(z_1) < \varphi_j(z_2)$.

$\rightarrow$ Comparative advantage in technologies:

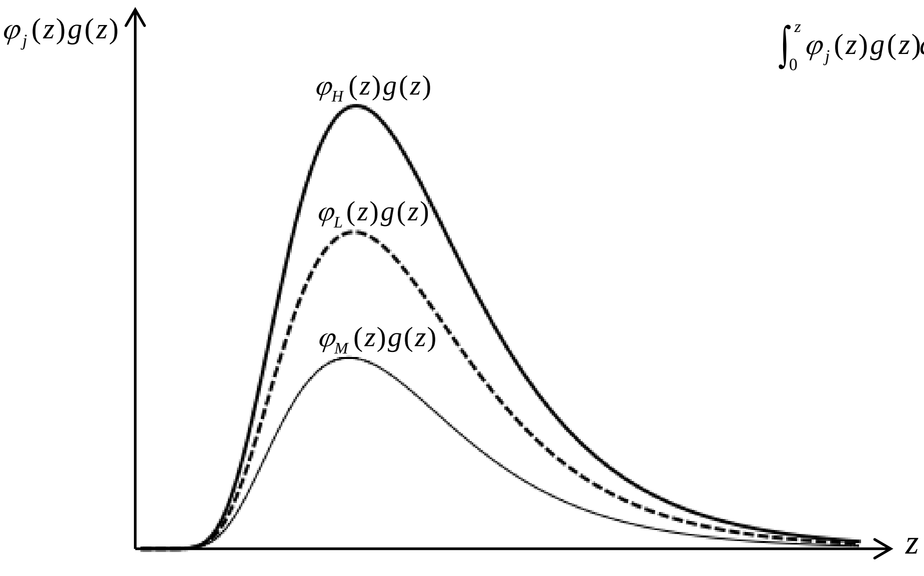
$$0 < \frac{\partial \varphi_M(z)}{\partial z} \frac{1}{\varphi_M(z)} < \frac{\partial \varphi_L(z)}{\partial z} \frac{1}{\varphi_L(z)} < \frac{\partial \varphi_H(z)}{\partial z} \frac{1}{\varphi_H(z)}.$$

$\longrightarrow$ Workers sort between technologies according to their respective comparative advantage.

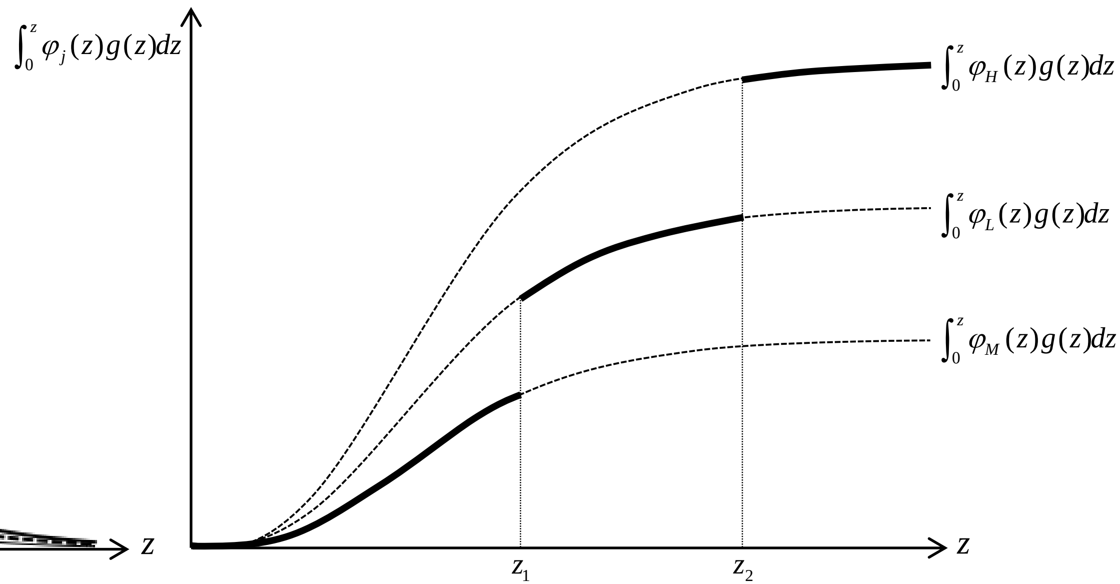


Technology-Augmented Skill Distribution (TASD)

- Total labor productivity will be determined not only by skill distribution $g(z)$, but also by employed technologies.
- With workers sorting into different technologies (tasks) based on their respective comparative advantage, the total labor productivity will be determined by skill-technology assignment in equilibrium.



TASD for each given technology j



Equilibrium TASD

Basic Setup: Innovation Sector

- Manufacturing firms bear fixed costs in the form of knowledge capital, developed by a perfectly competitive innovation sector.
- Sector-wide positive externality (Romer, 1990; Grossman and Helpman, 1991):
  - Effective units of labor to produce one unit of K:

$$a_I = \frac{1}{\lambda K}.$$

  - Flow of new K:

$$Q_K = \frac{L_I}{a_I}.$$

- I-sector workers have access to the most efficient H-tech:
  - Unit production cost of K:

$$C_K = C_H a_I.$$

Instantaneous Equilibrium

- Workers are paid their marginal product:

$$w(z)=\begin{cases} C_M \varphi_M(z), & z\in(0,z_1) \\ C_L \varphi_L(z), & z\in(z_1,z_2) \\ C_H \varphi_H(z), & z\in(z_2,\infty) \end{cases}$$

- No-arbitrage conditions for the threshold workers:

$$C_M = 1$$

$$C_L = C_M \frac{\varphi_M(z_1)}{\varphi_L(z_1)} \qquad \longrightarrow \qquad C_M > \underbrace{C_L > C_H}$$

$$C_H = C_L \frac{\varphi_L(z_2)}{\varphi_H(z_2)}$$

$\rightarrow$ Decreasing in z_1 and z_2

- Labor market clearing condition:

$$\int_0^{z_1} \varphi_M(z) g(z) dz = \int_{z_1}^{z_2} \varphi_L(z) g(z) dz \qquad \textit{(non-MNs)}$$

$$\int_{z_2}^{\infty} \varphi_H(z) g(z) dz - L_I = L^* \qquad \textit{(MNs)}$$

- + other equilibrium conditions: see paper.

Instantaneous Equilibrium

- Zero-profit conditions:

$$\frac{1}{\sigma} p_L x_L = \pi f_L \quad \text{and} \quad \frac{1}{\sigma} p_H x_H = \pi \left(f_H + f_O \right)$$

- Labor incomes in the North and in the South:

$$W = C_M \int_0^{z_1} \varphi_M(z) g(z) dz + C_L \int_{z_1}^{z_2} \varphi_L(z) g(z) dz + C_H \int_{z_2}^{\infty} \varphi_H(z) g(z) dz$$

$$W^* = C_M^* L^*$$

- Consumption:

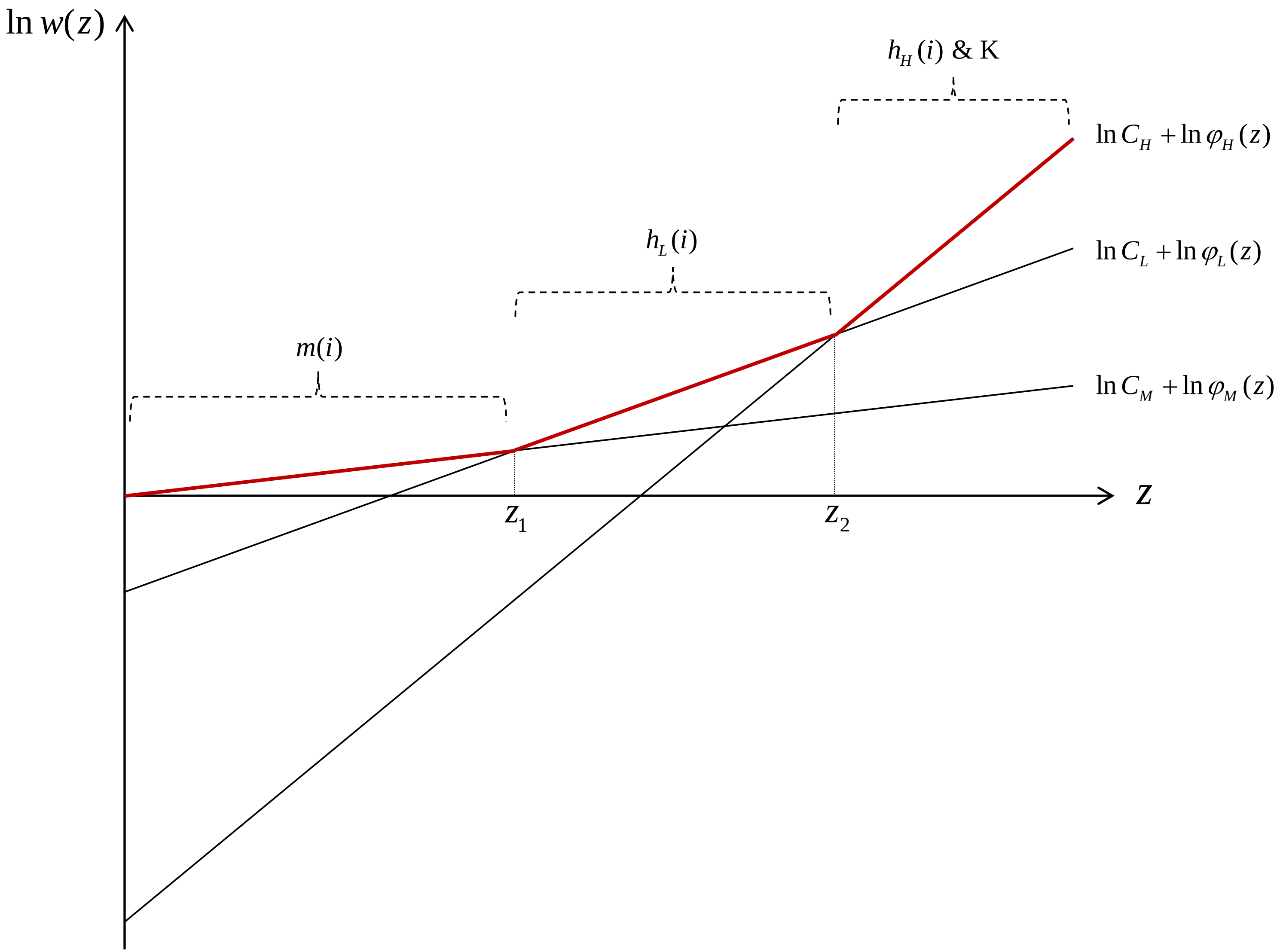
$$P_C C = E + E^*$$

$$E = W + \pi K - C_H L_I \quad \text{and} \quad E^* = W^*$$

- Technology and offshoring condition

$$\frac{1}{\sigma\pi} P_C^{\sigma} C \left[\frac{\sigma}{\sigma - 1} \left(C_L + C_M^* \right) \right]^{1-\sigma} - f_O \le f_L < f_H \le \frac{1}{\sigma\pi} P_C^{\sigma} C \left[\frac{\sigma}{\sigma - 1} \left(C_H + C_M^* \right) \right]^{1-\sigma} - f_O$$

Equilibrium Skill Allocation and Wage Distribution



Steady-State Growth

- Growth rate of K:

$$g \equiv \frac{\dot{K}}{K} = \frac{Q_K}{K} = \lambda L_I$$

$\rightarrow$ In steady state where $\dot{z_1} = 0$, $\dot{z_2} = 0$ and $\dot{L_I} = 0$, g is time invariant.

- Steady-state level of real investment L_I:
  - *Tobin's q*: capital's market value = replacement cost

Market value of a unit of K: $V_0 \equiv \int_{t=0}^{\infty} e^{-rt} \pi_t dt = \frac{\pi_0}{\rho + g}$

Replacement cost of K: $C_K = C_H a_I$

$$\rightarrow \quad L_I = \frac{\widetilde{W} + \widetilde{W}^*}{\sigma C_H} - \frac{\rho}{\lambda}\left(\frac{\sigma - 1}{\sigma}\right)$$

$$\rightarrow \quad g = \frac{\lambda(\widetilde{W} + \widetilde{W}^*)}{\sigma C_H} - \frac{\rho(\sigma - 1)}{\sigma}$$

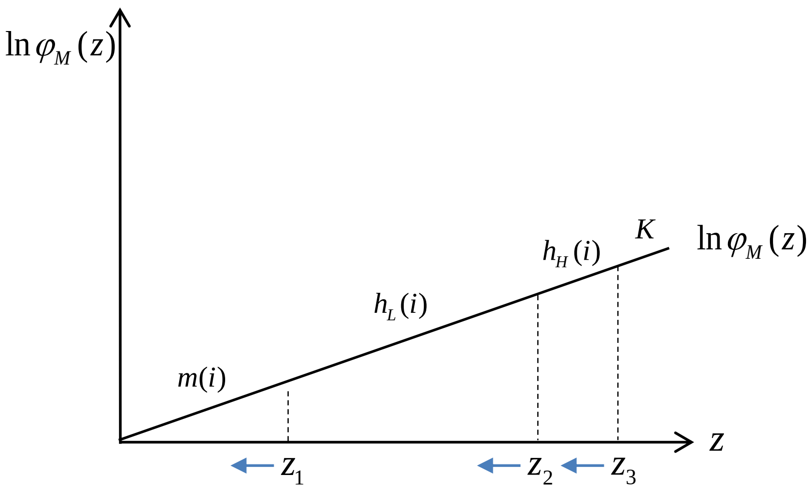
where $\widetilde{W} = C_M \int_0^{z_1} \varphi_M(z) g(z) dz + C_L \int_{z_1}^{z_2} \varphi_L(z) g(z) dz + C_H \int_{z_2}^{\infty} \varphi_H(z) g(z) dz,$

$\widetilde{W}^* = C_M^* L^*.$

- Steady-state growth rate is determined by two skill thresholds z_1 and z_2 !

Offshoring: Basic Mechanism

- One technology case
  - Domestically only one technology M: C_M with f_M
  - Offshoring decision for $m(i)$: $C_M > C_M^*$ with $f_O > 0$



→ Revenue ratio MNs vs. non-MNs

$$\frac{C_M + C_M^*}{2C_M} = \left[\frac{f_M + f_O}{f_M}\right]^{\frac{1}{1-\sigma}}$$

→ $\frac{dC_M^*}{df_O} < 0$ (with $\overline{L^*}$)

→ No domestic income change, but a rise in income in the South

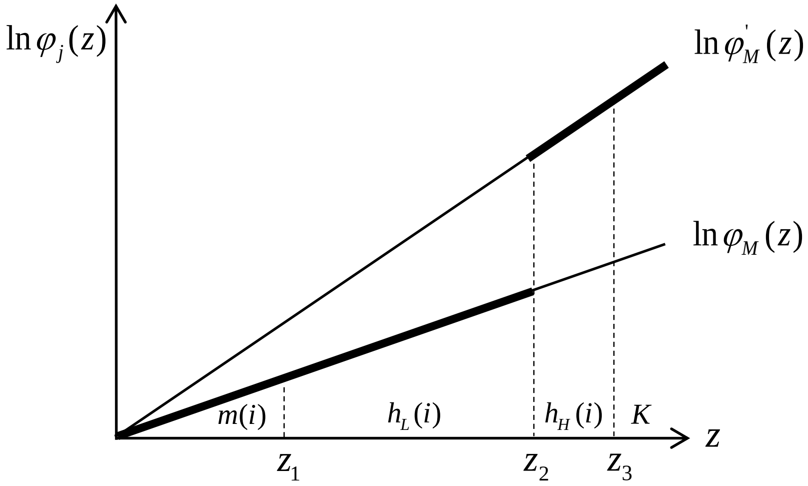
→ Rises in L_I and g;

→ Leftward shifts of z_1, z_2, and z_3

Lemma 1 *Even when only one technology exists (thus, without technology-upgrading effects), offshoring increases domestic growth rate by exploring Southern labor.*

Offshoring: Basic Mechanism Cont'd

- Two technology case
  - Domestically two technologies $M' > M$: $C_M' < C_M$ with $f_M' > f_M$
  - Offshoring decision for $m(i)$: $C_M > C_M^*$ with $f_O > 0$



→ Revenue ratio MNs vs. non-MNs

$$\frac{C_M^{'} + C_M^*}{2C_M} = \left[\frac{f_M^{'} + f_O}{f_M} \right]^{\frac{1}{1-\sigma}}$$

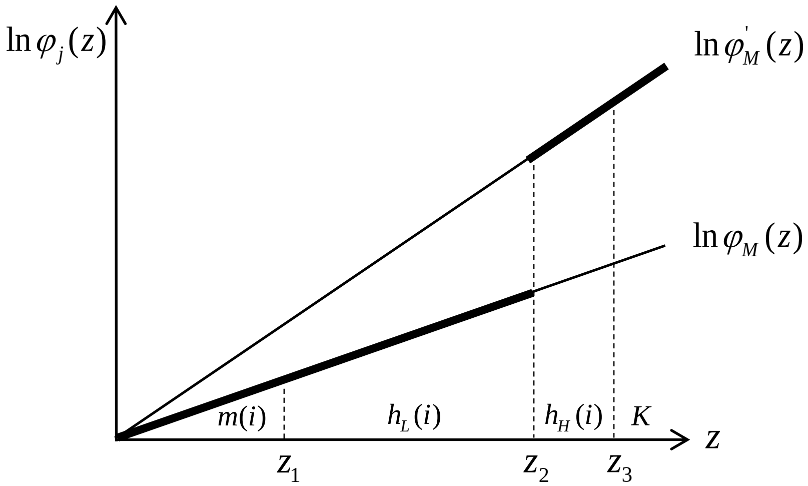
$$\frac{C_M^{'} + C_M^*}{2C_M} = \left[\frac{f_M^{'} + f_O}{f_M} \right]^{\frac{1}{1-\sigma}}$$

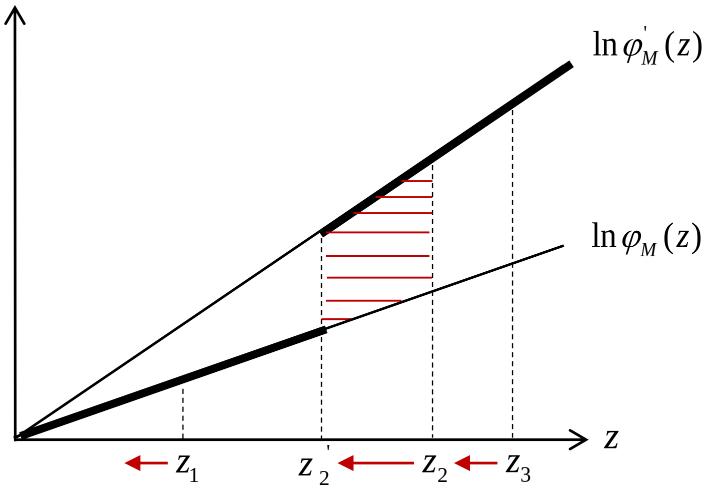
→ $\frac{dC_M'}{df_O} < 0$ (with $\overline{C_M^*}$),

implying a leftward shift of z_2

Offshoring: Basic Mechanism Cont'd

- Two technology case





→ Economy-wide increased efficiency units of labor due to technology-upgrading mechanism

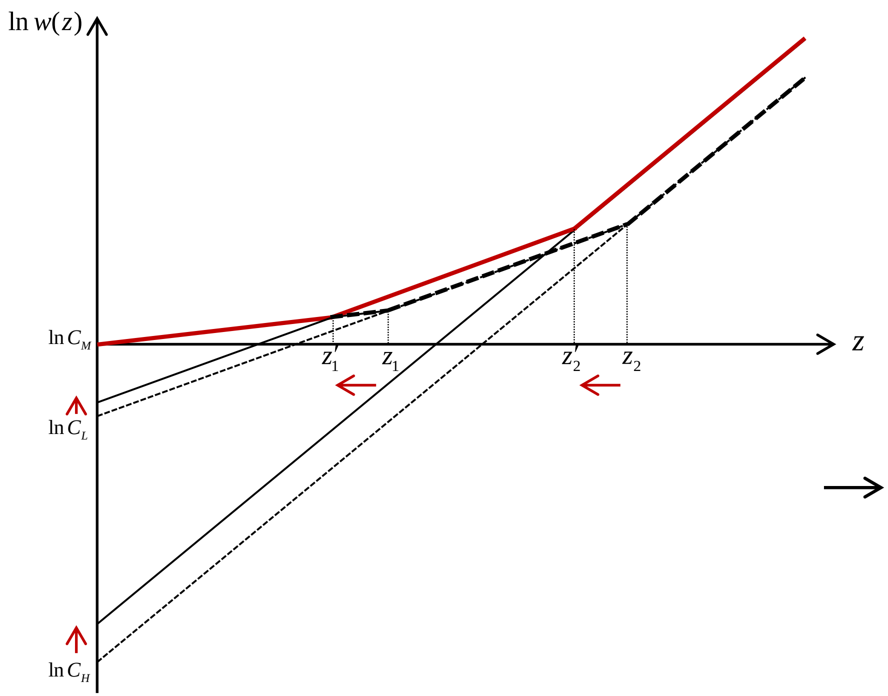
→ Scale effects of growth, not due to increased population size but due to increased efficiency units of labor at a given population size

Lemma 2 *When technological difference exists between MNs and non-MNs, offshoring increases domestic growth rate even further due to technology upgrading effects.*

Offshoring: $df_O < 0$

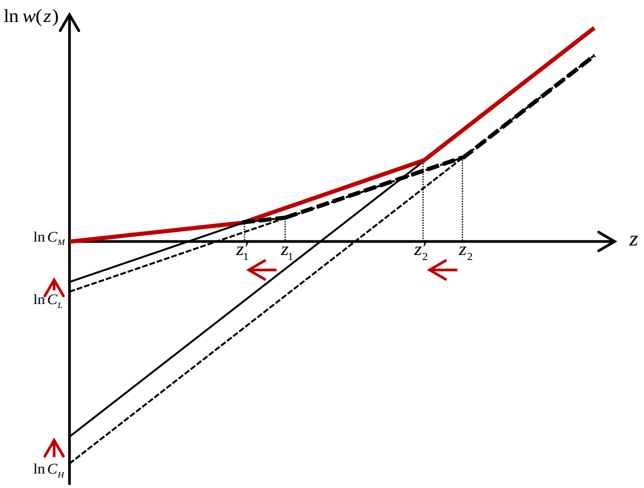
- A fall in f_O decreases two skill thresholds z_1 and z_2: $\frac{dz_1}{df_O} > 0$ and $\frac{dz_2}{df_O} > 0$.
  - Labor market clearing: $\int_0^{z_1} \varphi_M(z) g(z) dz = \int_{z_1}^{z_2} \varphi_L(z) g(z) dz$
  - Revenue ratio *MNs* vs. *non-MNs*: $\frac{C_H + C_M^*}{C_L + C_M} \equiv \frac{\alpha_1(z_1)\alpha_2(z_2) + C_M^*}{\alpha_1(z_1) + C_M} = \left[\frac{f_H + f_O}{f_L}\right]^{\frac{1}{1-\sigma}}$

- A fall in f_O increases unit production costs (or technology-specific efficiency wage rates) so that: $dC_L > 0$, $dC_H > 0$ and $d(C_H/C_L) > 0$.



$\longrightarrow$ A fall in f_O generates technology-upgrading mechanisms at both individual worker and firm levels.

Offshoring: $df_O < 0$



Proposition 1 *A fall in f_O decreases two skill thresholds z_1 and z_2: $\frac{dz_1}{df_O} > 0$ and $\frac{dz_2}{df_O} > 0$.*

Corollary 1 *A fall in f_O increases unit production costs so that: $\frac{dC_L}{df_O} < 0$, $\frac{dC_H}{df_O} < 0$, and $\frac{d\left(\frac{C_H}{C_L}\right)}{df_O} < 0$.*

- Market concentration effect:

$$\frac{N_H}{N_L} = \left(\frac{f_L}{f_H + f_O}\right)^{\frac{\sigma}{\sigma-1}} \frac{\int_{z_2}^{\infty} \varphi_H(z) g(z) dz - L_I}{\int_0^{z_1} \varphi_M(z) g(z) dz}$$

Proposition 2 *A fall in f_O increases N_H and decreases N_L so that $\frac{N_H}{N_L}$ increases.*

Offshoring: Static Welfare Effects

$$P_C = \frac{\sigma}{\sigma - 1}\left[N_L \left(C_L + C_M \right)^{1-\sigma} + N_H \left(C_H + C_M^* \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

1) P_C-increasing forces:

   – Prices (both p_L and p_H) increase.

   – Total number of varieties ($N_L + N_H$) decreases.

2) P_C-decreasing force:

   – $dN_H > 0$ and $dN_L < 0$ $\rightarrow$ More varieties at cheaper price ($p_H < p_L$).

$\Rightarrow$ In total, ambiguous !

   – If there would be any welfare losers(winners), $M(H)$-workers would be affected the most negatively(positively).

$\Rightarrow$ However, a fall in f_O increases the aggregate welfare: $\left(\frac{E}{P_C}\right)/\, df_O < 0$.

Proposition 3 *A fall in f_O increases real income $\frac{E}{P_C}$.*

Offshoring: Growth Effects

$$L_I = \frac{1}{\sigma}\left[\underbrace{\frac{C_L + C_M}{C_H}}_{(1)} \underbrace{\int_0^{z_1} \varphi_M(z) g(z) dz}_{(2)} + \underbrace{\int_{z_2}^{\infty} \varphi_H(z) g(z) dz}_{(3)} + \underbrace{\frac{C_M^*}{C_H}}_{(1)'} \underbrace{L^*}_{(4)}\right] - \frac{\rho}{\lambda}\left(\frac{\sigma - 1}{\sigma}\right)$$

- Four offshoring-and-growth links:
  - *i. Redistribution effect:* (1) Domestic: $\frac{C_L + C_M}{C_H} \downarrow$
    (1)' International: $\frac{C_M^*}{C_H} \downarrow$
  - *ii. Displacement effect:* (2) $\int_0^{z_1} \varphi_M(z) g(z) dz \downarrow$
  - *iii. Technology-upgrading effect:* (3) $\int_{z_2}^{\infty} \varphi_H(z) g(z) dz \nearrow$
  - *iv. South-employment effect:* (4) $L^* \nearrow$

(i), (ii): Anti-growth

$\wedge$

(iii), (iv): Pro-growth

$\Rightarrow$ Pro-growth effects dominate anti-growth effects: A fall in f_O increases the steady-state level of real investment L_I, and thus enhances growth.

Offshoring: Growth Effects

Proposition 4 *We identify four offshoring-and-growth effects: (i) redistribution, (ii) displacement, (iii) technology-upgrading, and (iv) South-employment, of which the first two slow growth while the latter two stimulate it.*

Proposition 5 *A fall in* f_O *increases the steady-state level of real investment* L_I*, and thus enhances growth.*

- See paper for mathematical proofs.

Numerical Appraisal: Calibration

- Log-normal skill distribution & linear technologies

$$g(z) = \frac{1}{z\sqrt{2\pi\varepsilon}} e^{-\frac{(\ln z - \mu)^2}{2\varepsilon^2}}, \qquad z \in (0, \infty)$$
$$\varphi_j(z) = 1 + a_j z, \qquad j \in \{M, L, H\}$$

- MNs use β share of foreign inputs and $(1-\beta)$ share of domestic inputs.

- $C_M^* = 0.63; \rho = 0.05; \sigma = 4; f_L = 1.0; f_H = 1.2;\ f_O = 0.1.$

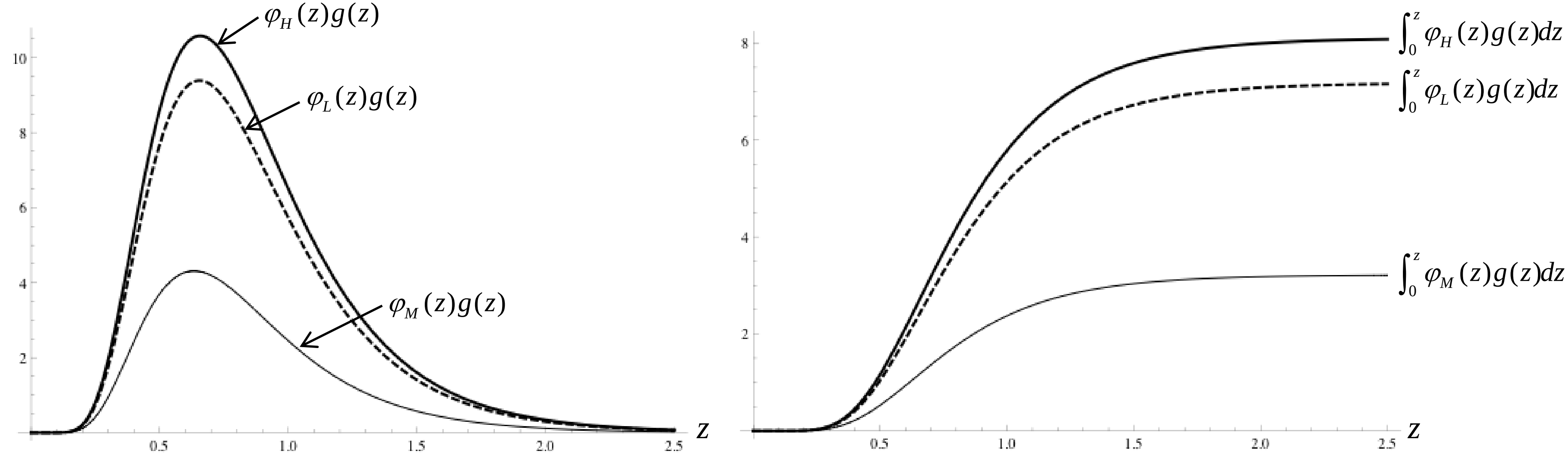
- Calibration of key parameter values using US data:

  – Ratio of production workers, non-production workers' wage share, MNs' total output value share, productivity difference estimate between MNs and non-MNs, Gini index, US real GDP growth rate, average foreign-input share of US offshoring firms, etc.

$\rightarrow$ $\mu = -0.80; \varepsilon = 0.83; a_M = 0.35; a_L = 1.98; a_H = 2.27; \lambda = 0.09; \beta = 0.20.$

$\rightarrow$ Calibrated log-normal skill distribution exhibits a mean of 0.64, a variance of 0.41 and a skewness of 3.97.

- Calibrated Technology-Augmented Skill Distribution (TASD):



$(a)\quad \varphi_j(z)g(z)$

$(b)\quad \int_0^z \varphi_j(z)g(z)dz$

Effects of falls in f_O and C_M^*

	Fall in f_O					Fall in C_M^*				
	1.00	0.98	0.96	0.94	0.92	1.00	0.99	0.98	0.97	0.96
z_1^0	0.0000	-0.0037	-0.0076	-0.0115	-0.0156	0.0000	-0.0065	-0.0133	-0.0203	-0.0274
z_2^0	0.0000	-0.0592	-0.1132	-0.1626	-0.2081	0.0000	-0.1001	-0.1854	-0.2589	-0.3229
C_L^0	0.0000	0.0014	0.0029	0.0044	0.0060	0.0000	0.0025	0.0051	0.0079	0.0107
C_H^0	0.0000	0.0030	0.0060	0.0091	0.0123	0.0000	0.0052	0.0106	0.0161	0.0216
N_L^0	0.0000	-0.0582	-0.1174	-0.1773	-0.2378	0.0000	-0.1025	-0.2069	-0.3119	-0.4168
N_H^0	0.0000	0.3598	0.7267	1.0991	1.4758	0.0000	0.6298	1.2709	1.9161	2.5602
$N_L^0 + N_H^0$	0.0000	-0.0117	-0.0235	-0.0353	-0.0471	0.0000	-0.0210	-0.0424	-0.0640	-0.0855
$Gini^0$	0.0000	0.0072	0.0134	0.0183	0.0221	0.0000	0.0119	0.0202	0.0246	0.0248
L^{*0}	0.0000	0.3626	0.7339	1.1126	1.4974	0.0000	0.6415	1.3035	1.9796	2.6638
L^{eff0}	0.0000	0.0033	0.0067	0.0101	0.0136	0.0000	0.0058	0.0118	0.0178	0.0237
L_I^0	0.0000	0.0043	0.0088	0.0134	0.0182	0.0000	0.0073	0.0147	0.0222	0.0295
g^0	0.0000	0.0043	0.0088	0.0134	0.0182	0.0000	0.0073	0.0147	0.0222	0.0295

Welfare Effects of falls in f_O and C_M^*

	Fall in f_O					*Fall in* C_M^*				
	1.00	0.98	0.96	0.94	0.92	1.00	0.99	0.98	0.97	0.96
P_C^0	0.0000	0.0005	0.0010	0.0015	0.0021	0.0000	0.0009	0.0018	0.0027	0.0037
$Welf_{Agg}^0$	0.0000	0.0007	0.0014	0.0022	0.0030	0.0000	0.0012	0.0026	0.0040	0.0055
$Welf_M^0$	0.0000	-0.0005	-0.0010	-0.0015	-0.0021	0.0000	-0.0009	-0.0018	-0.0027	-0.0036
$Welf_L^0$	0.0000	0.0009	0.0019	0.0029	0.0039	0.0000	0.0016	0.0034	0.0052	0.0070
$Welf_H^0$	0.0000	0.0025	0.0050	0.0076	0.0102	0.0000	0.0044	0.0088	0.0133	0.0179
$ItWelf_{Agg}^0$	0.0000	0.0018	0.0036	0.0056	0.0076	0.0000	0.0031	0.0063	0.0096	0.0130
$ItWelf_M^0$	0.0000	0.0006	0.0012	0.0018	0.0025	0.0000	0.0010	0.0019	0.0029	0.0037
$ItWelf_L^0$	0.0000	0.0020	0.0041	0.0063	0.0085	0.0000	0.0035	0.0071	0.0108	0.0145
$ItWelf_H^0$	0.0000	0.0036	0.0072	0.0110	0.0148	0.0000	0.0062	0.0126	0.0190	0.0254

$\Rightarrow$ Intertemporal welfare effects: equivalent variation index ϕ

$$(1+\phi)\int_{t=0}^{\infty} e^{-\rho t}\ln\left(\frac{Ee^{\frac{g_0}{\sigma-1}}}{P_{C0}}\right)dt = \int_{t=0}^{\infty} e^{-\rho t}\ln\left(\frac{Ee^{\frac{g_1}{\sigma-1}}}{P_{C1}}\right)dt$$

Effects of a rise in μ

	Rise in μ					*Rise in μ at a given mean*				
	-0.7926	-0.7876	-0.7826	-0.7776	-0.7726	-0.7926	-0.7876	-0.7826	-0.7776	-0.7726
ε^0	0.8313	0.8313	0.8313	0.8313	0.8313	0.8313	0.8252	0.8191	0.8130	0.8068
N_L^0	0.0000	-0.0022	-0.0044	-0.0067	-0.0089	0.0000	0.0064	0.0129	0.0195	0.0262
N_H^0	0.0000	0.0136	0.0273	0.0410	0.0550	0.0000	-0.0394	-0.0795	-0.1200	-0.1612
P_C^0	0.0000	-0.0008	-0.0015	-0.0023	-0.0030	0.0000	0.0000	-0.0001	-0.0001	-0.0002
g^0	0.0000	0.0075	0.0151	0.0227	0.0303	0.0000	-0.0026	-0.0051	-0.0078	-0.0104
$Welf_{Agg}^0$	0.0000	0.0012	0.0023	0.0035	0.0047	0.0000	-0.0007	-0.0014	-0.0020	-0.0027
$ItWelf_{Agg}^0$	0.0000	0.0031	0.0061	0.0092	0.0124	0.0000	-0.0013	-0.0026	-0.0040	-0.0053

$\Rightarrow$ A rise in μ at a given ε (skill upgrading) increases welfare and growth due to technology-upgrading.

$\Rightarrow$ A rise in μ at a given mean (a decrease in ε) decreases welfare and growth due to technology-downgrading.

Concluding Remarks

- We have developed an endogenous growth model in which heterogeneous workers in skill endogenously sort into different technologies/tasks based on their comparative advantage.
- We have highlighted the technology-skill-growth and offshoring-growth links within a unified multi-task/technology-based heterogeneous worker framework.
  - → Richer predictions (empirically testable) on the relationship between labor market changes and growth.
  - → Static and dynamic welfare implications for different worker groups on the skill ladder.
  - → Technology up- and downgrading mechanism at both individual worker and firm levels.
- Economic policy implications:
  - → Any policy on either technology or population skill without considering the interplay between them might lead to different results not only quantitatively but also even qualitatively.

Thank you for listening!