

Globalization of Software Development



Ashish Arora

Carnegie Mellon University

Matej Drev

Carnegie Mellon University

Chris Forman

Carnegie Mellon University

Motivation

- ❑ Rate of globalization of software services has been high
- ❑ Recent field study work has suggested more software R&D activities are taking place abroad
 - India: Growth of innovative sector of small niche companies, particularly in embedded systems (e.g., Athreye 2005, Arora 2006)
 - Ireland, China: Similar trends in increasing inventive activity (Sands 2005, Tschang and Xue 2005)
 - Brazil, Israel: Long have had product-based software industry (Breznitz 2005, Botelho, Stefanuto, and Veloso 2005)
- ❑ Need systematic measure of inventive activity

What we do

- Examine geographic distribution of the site of software patenting activity worldwide (using inventor location)
- Examine extent to which patents invented abroad are assigned to US MNCs
- Decompose software patenting activity by “industry”
 - This is not easy because of way USPTO classifies patents
 - Seek to examine how user innovation shapes location of inventive activity

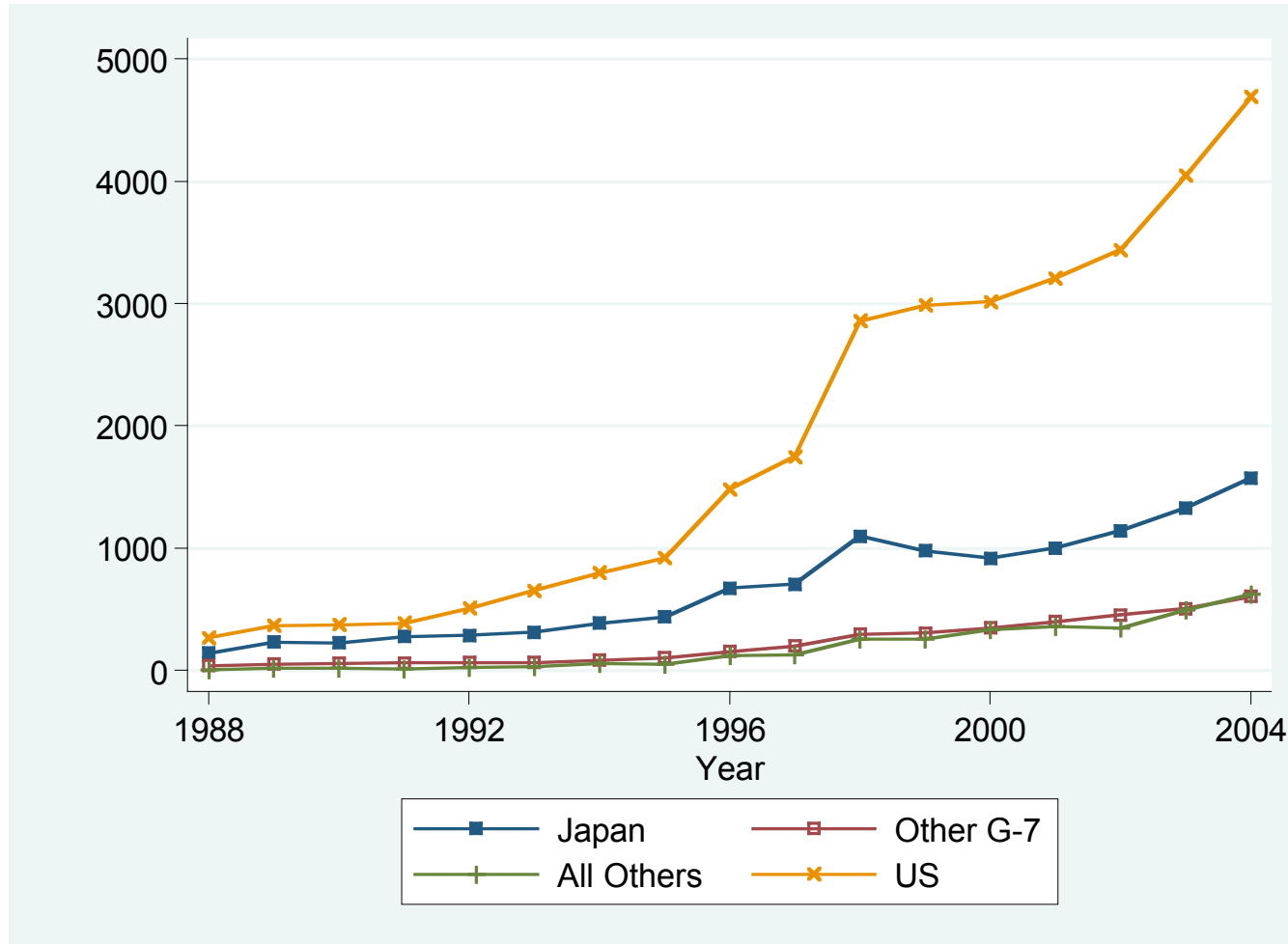
What we find

- Site of inventive activity in software continues to be concentrated in US and predominately assigned to US firms
 - Though an increasing share of patents invented abroad are assigned to US firms, little evidence of shift to offshore location for patents assigned to US firms
- Inventive activity in software outside of the US tends to be more concentrated in software whose development requires less interaction with users

Use of US patent data to measure location of inventive activity

- What exactly is a software patent? Since software is often an input into other inventions, it is found throughout the USPTO classification system
- Several methods have been proposed to identify software patents
 - Classification-based (Graham and Mowery 2003, 2005; Hall and MacGarvie 2006)
 - Key word based (Bessen and Hunt 2004)
 - Intersection of two (Cockburn and MacGarvie 2006; Hall and MacGarvie 2006)
- We use a combination of methods

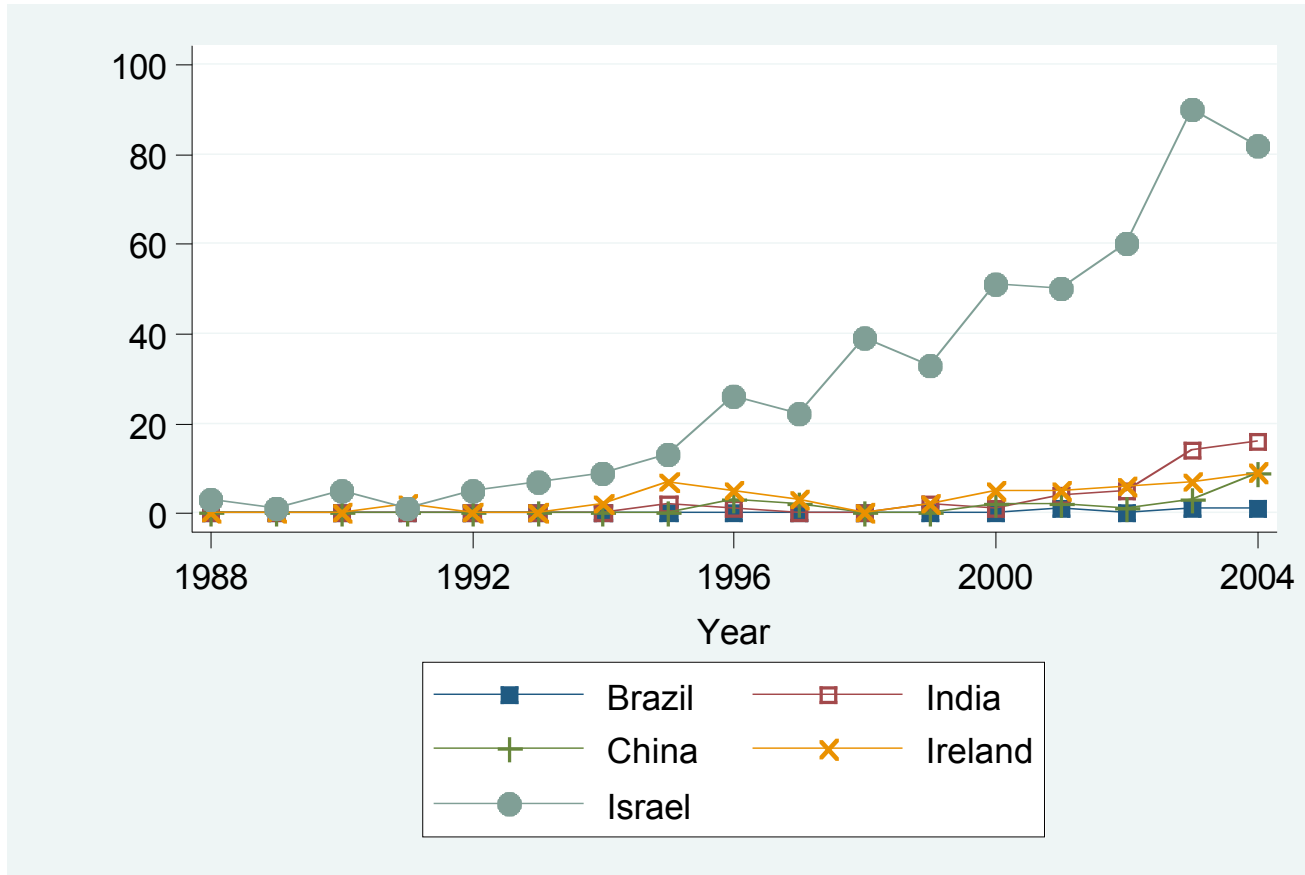
Inventive activity in software continues to be concentrated in the US



US Software Patents invented in US and Other Countries

Source: USPTO data and author's calculations

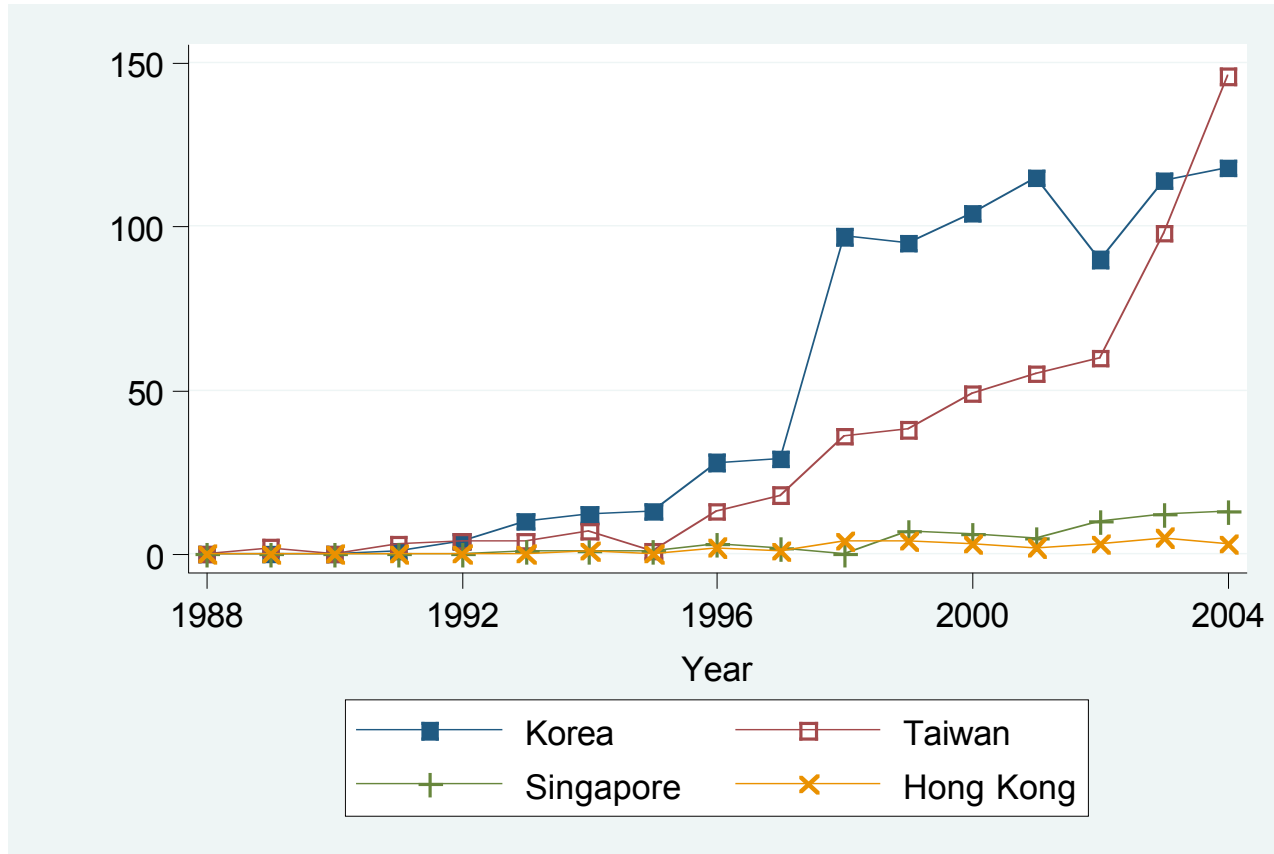
Few software patents have been granted to inventors in the software underdogs



Number of US Software Patents Invented in Underdog Countries

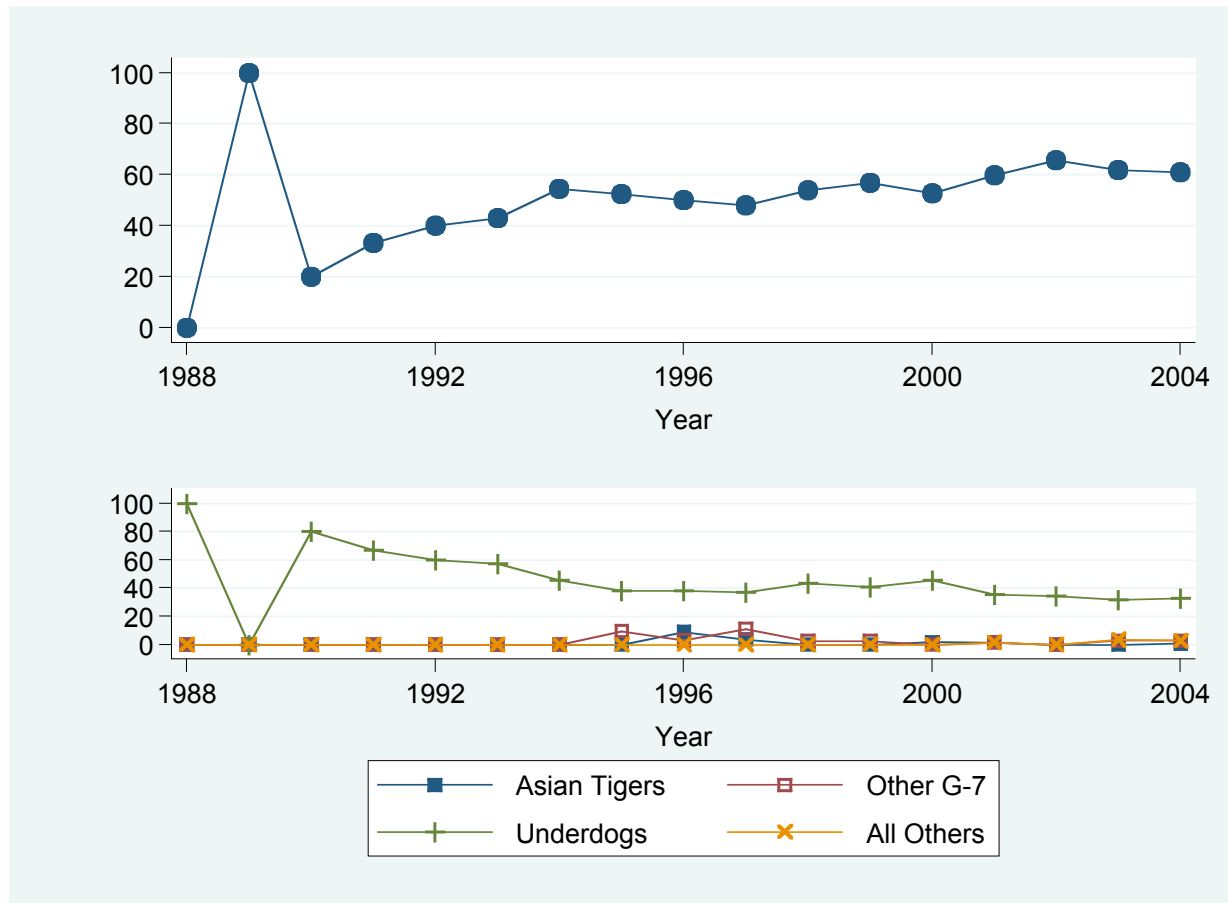
Source: USPTO data and author's calculations

More software patents in the Asian Tigers, but many are electronics-related



Number of US Software Patents Invented in East Asian Tigers

An increasing share of patents invented in underdogs are assigned to US firms



Percent of Patents Assigned to Firms in Region for US Software Patents Invented in Software Underdogs (Top Panel US; Bottom Panel All Others)

How does globalization of software invention vary by industry?

- Some dimensions that may influence where to locate inventive activity in software
 - Distance to technical frontier: Proximity to US universities and highly skilled software labor (e.g., Thursby and Thursby 2006)
 - Proximity to lead users: Transition of new inventions to usable economic products often is a difficult process, often requires user inputs (e.g., Rosenberg 1963; Rosenberg 1983)

Importance of lead user innovation varies by software industry

- User co-invention has been found to be particularly important to enterprise software that is embedded in business processes (Bresnahan and Greenstein 1996)
- Likely less important for new software tools and technical enhancements that are not connected with business processes

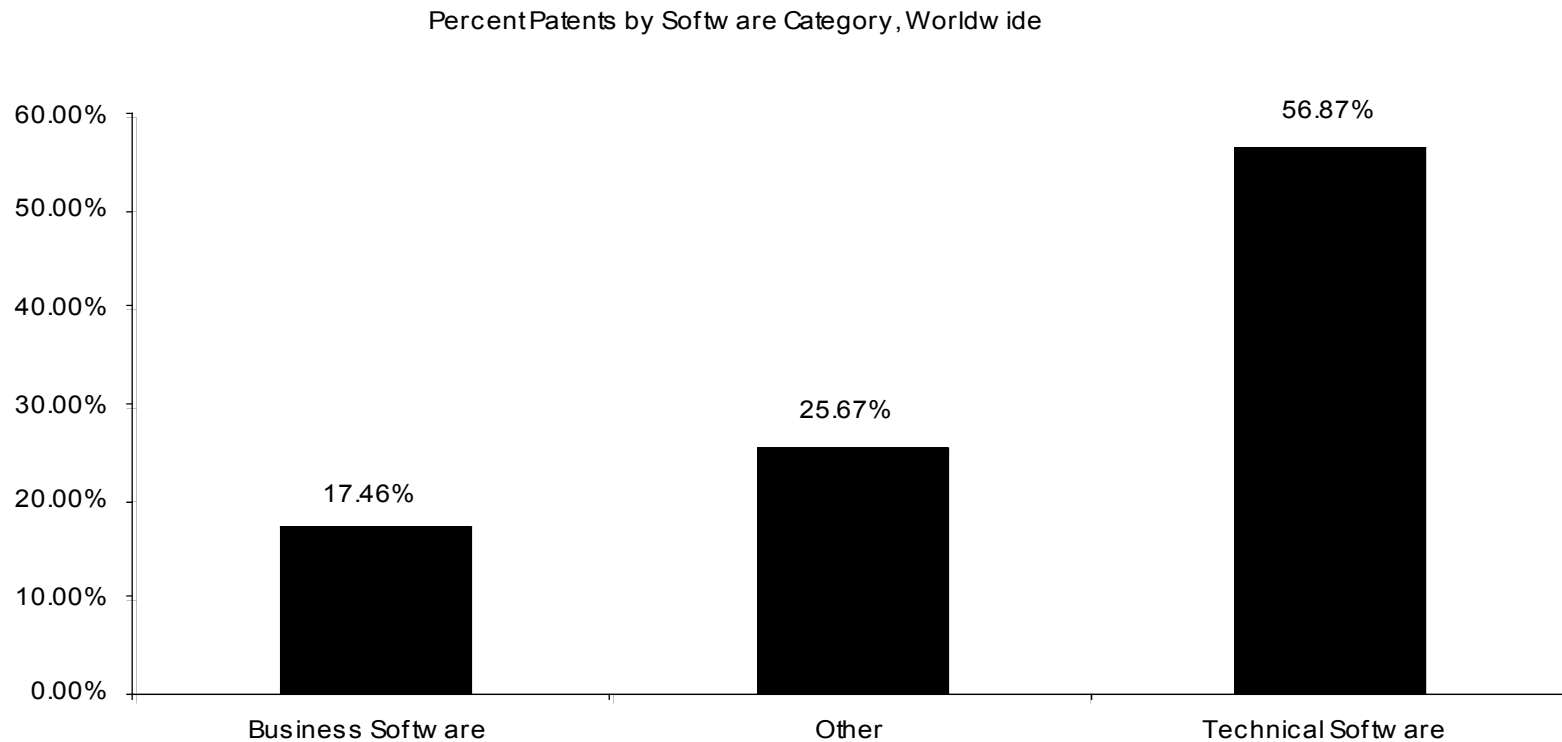
Classifying software patents

- ❑ Existing classification systems (e.g., USPTO, IPC) are based upon technological rather than market differences
- ❑ Need to derive independent classification system based upon software markets
- ❑ We use text mining to perform this classification
 - Use features (words) of patents to group similar patents together
- ❑ Cockburn and MacGarvie (2006) develop another classification system based on USPTO classes and citation patterns
 - Our results are robust to use of their classification system

Use of text mining to classify software patents

- Use industry classification system in Corptech database of technology companies
 - e.g., artificial intelligence, warehousing/distribution, transportation software, utility software
 - Aggregated some classes together which were small and similar
- Develop training set of patents for which we know the classification
 - Patents in single industry firms
- Feature selection: words in patent abstract and title (also experimented with description, claims)
 - Also used USPTO and IPC classes as features

Percent of all software patents by category

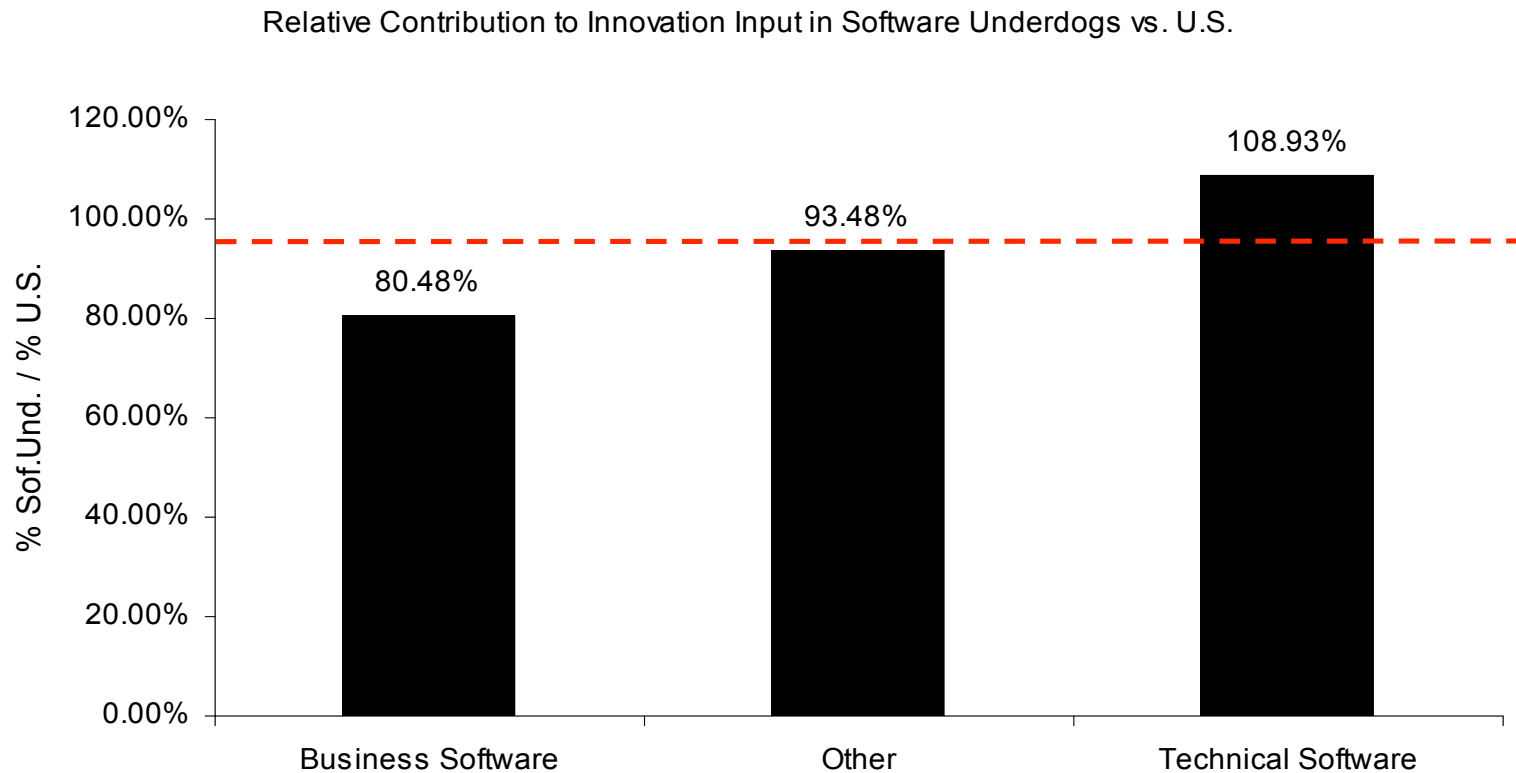


Percent of Patents Invented in Each Software Category Worldwide, 1989-2005

14

Source: USPTO data and author's calculations

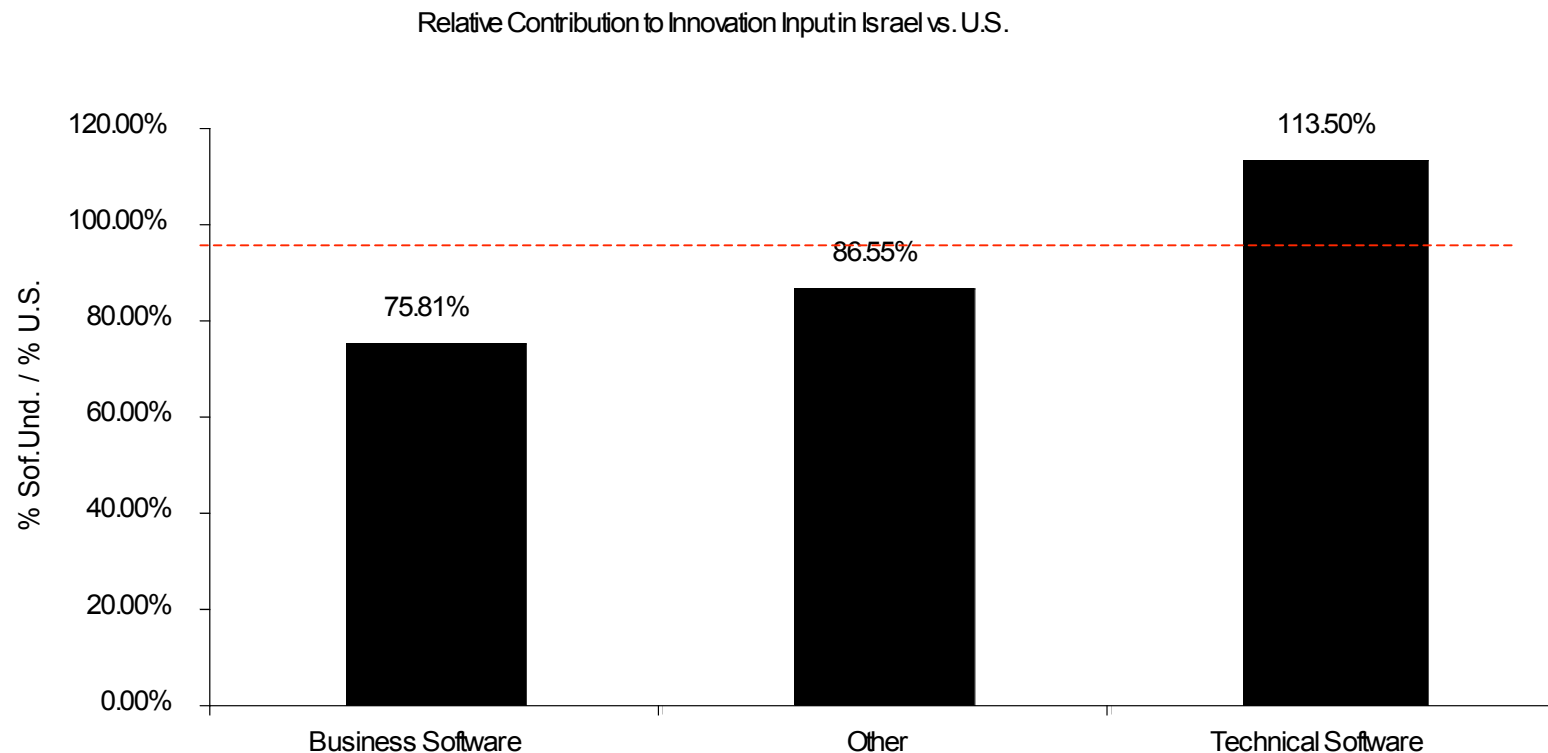
Software Underdogs are less likely to patent in enterprise software



Percent of Patents Invented in Each Software Category in Underdogs, normalized by comparable US percentage, 1989-2005₁₅

Source: USPTO data and author's calculations

However, there is variation within the underdogs: Israel



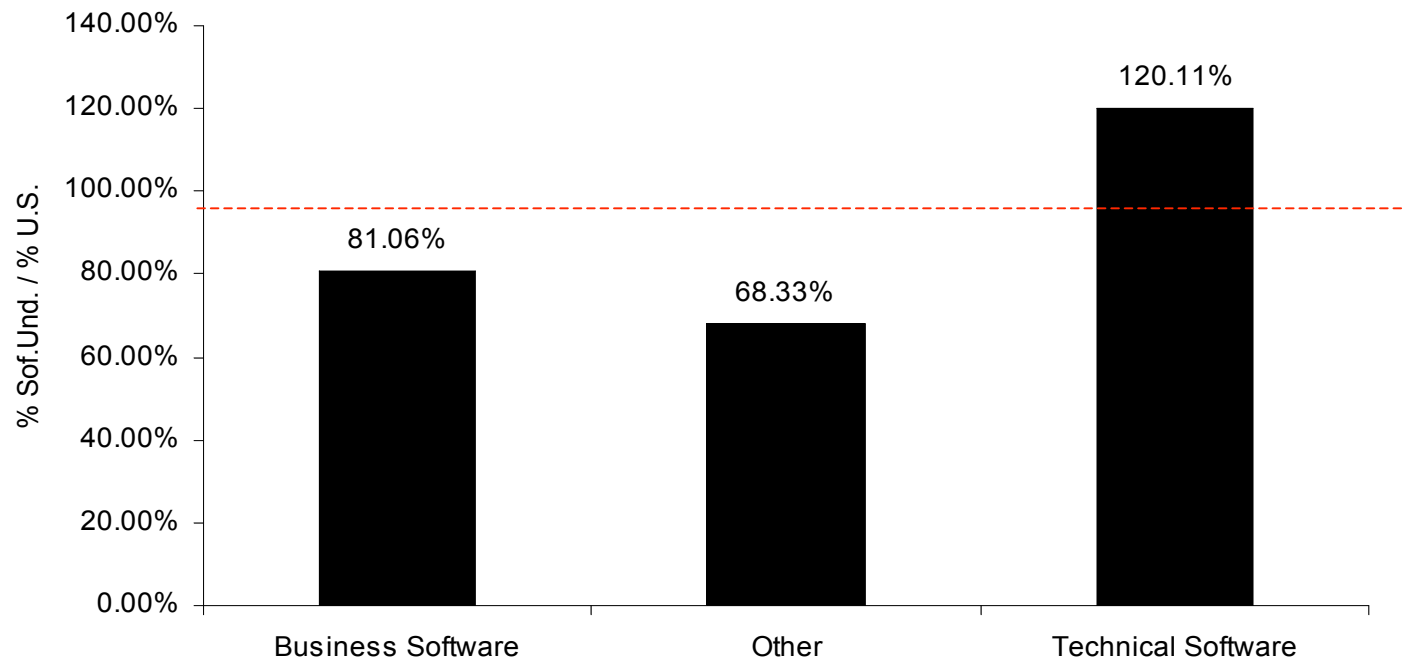
Percent of Patents Invented in Each Software Category in Israel, normalized by comparable US percentage, 1989-2005

16

Source: USPTO data and author's calculations

Variation within the underdogs: Ireland

Relative Contribution to Innovation Input in Ireland vs. U.S.



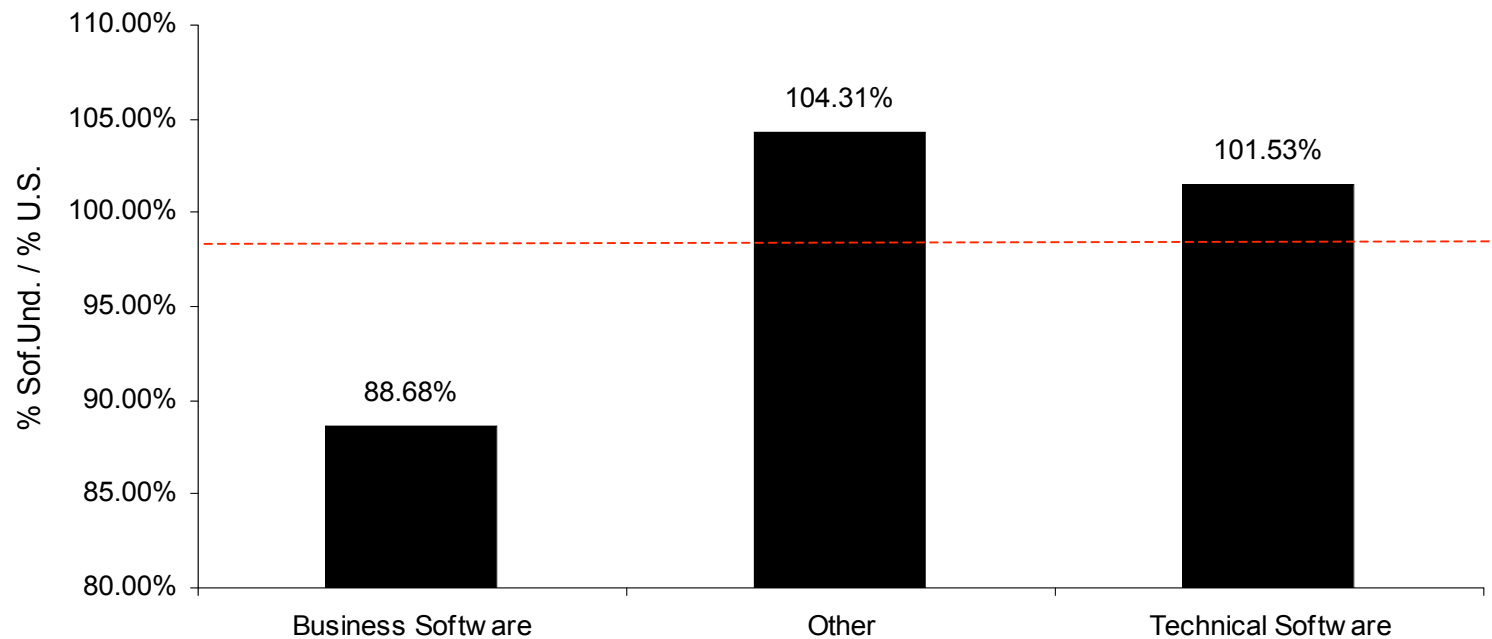
Percent of Patents Invented in Each Software Category in Ireland, normalized by comparable US percentage, 1989-2005

17

Source: USPTO data and author's calculations

Variation within the underdogs: China

Relative Contribution to Innovation Input in China vs. U.S.

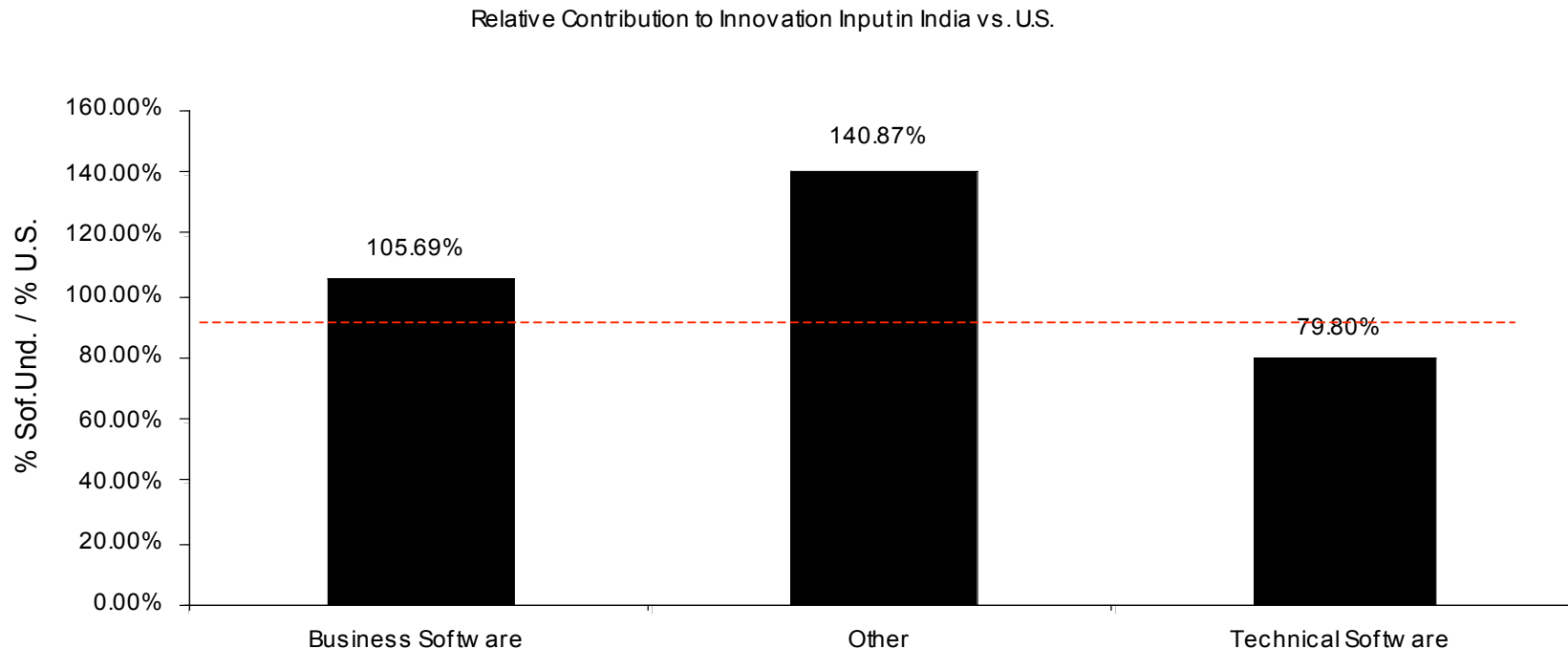


Percent of Patents Invented in Each Software Category in China, normalized by comparable US percentage, 1989-2005

18

Source: USPTO data and author's calculations

However, there is variation within the underdogs: India

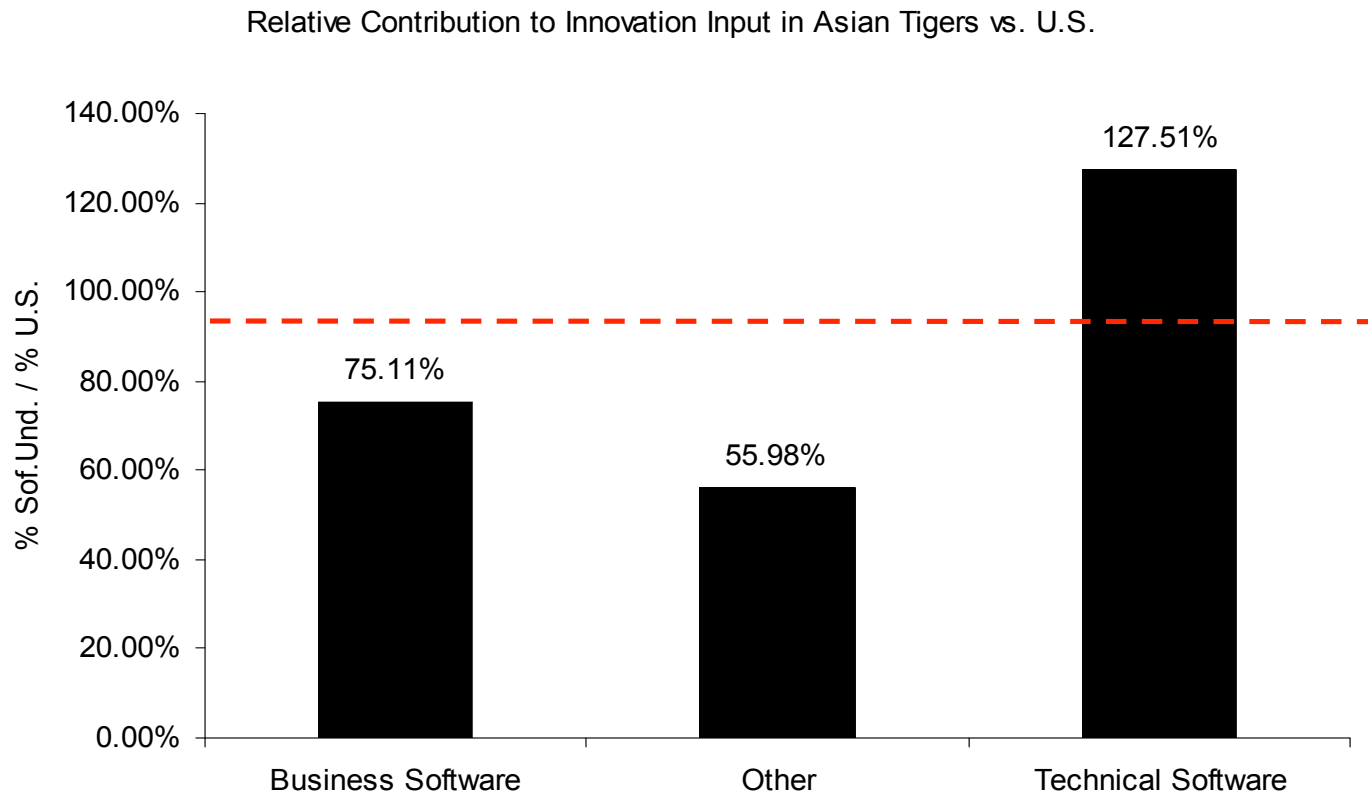


Percent of Patents Invented in Each Software Category in India, normalized by comparable US percentage, 1989-2005

19

Source: USPTO data and author's calculations

Asian tigers also predominately patent in technical areas

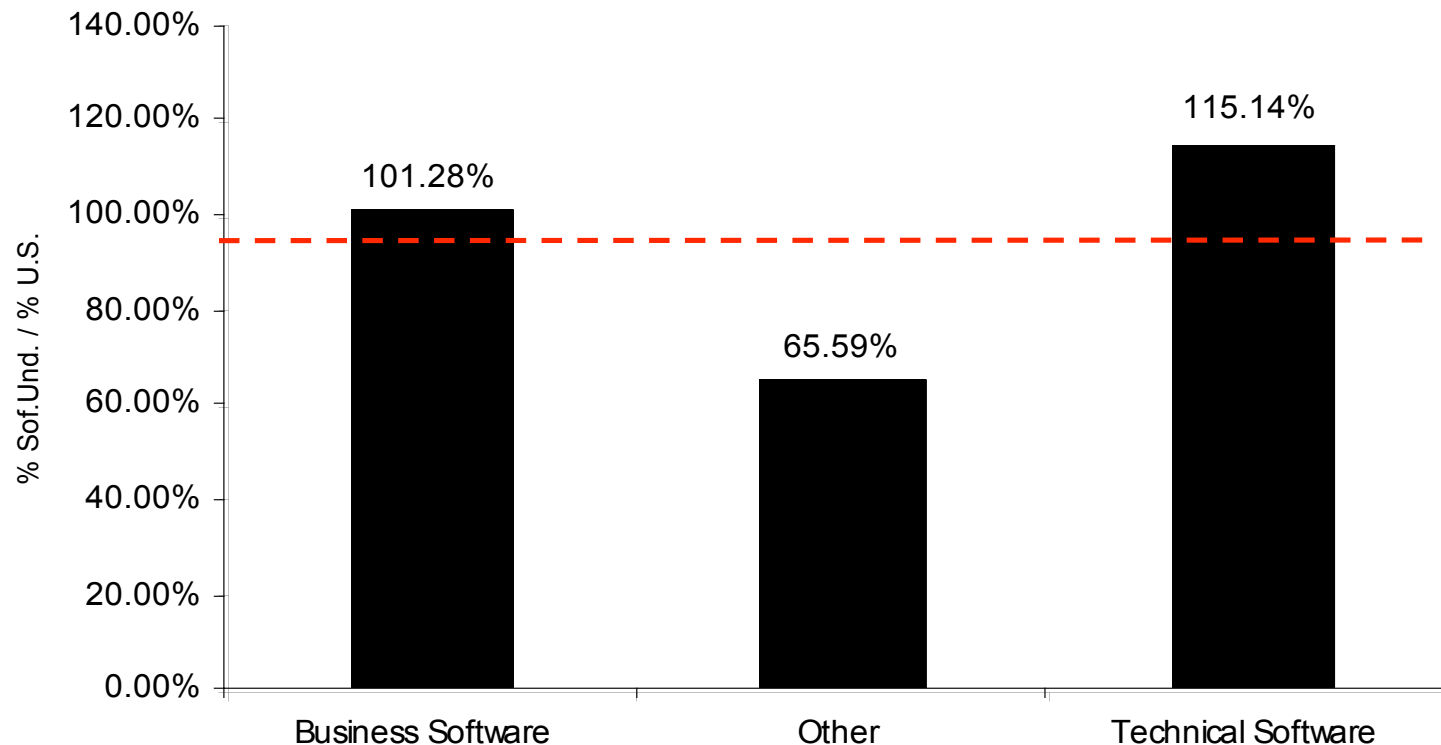


Percent of Patents Invented in Each Software Category in Asian Tigers, normalized by comparable US percentage, 1989-2005

Source: USPTO data and author's calculations

Other industrialized countries are relatively more likely to patent in enterprise software

Relative Contribution to Innovation Input in G8 (w/o US) vs. U.S.



Percent of Patents Invented in Each Software Category in non-US²¹ G8, normalized by comparable US percentage, 1989-2005

Conclusions

- Considerable evidence that US continues to lead in inventive activity in software
- US MNCs account for large and increasing share of patents invented in software underdogs
 - However, relatively little evidence of shift in inventive activity assigned to US firms abroad
- Demonstrate that lead user innovation shapes location of inventive activity
 - Inventive activity offshore is primarily in “technical” software industries

Next Steps

- Field work to further understand the mechanisms driving our results
- Additional empirical analysis of the factors shaping the site of inventive activity in software

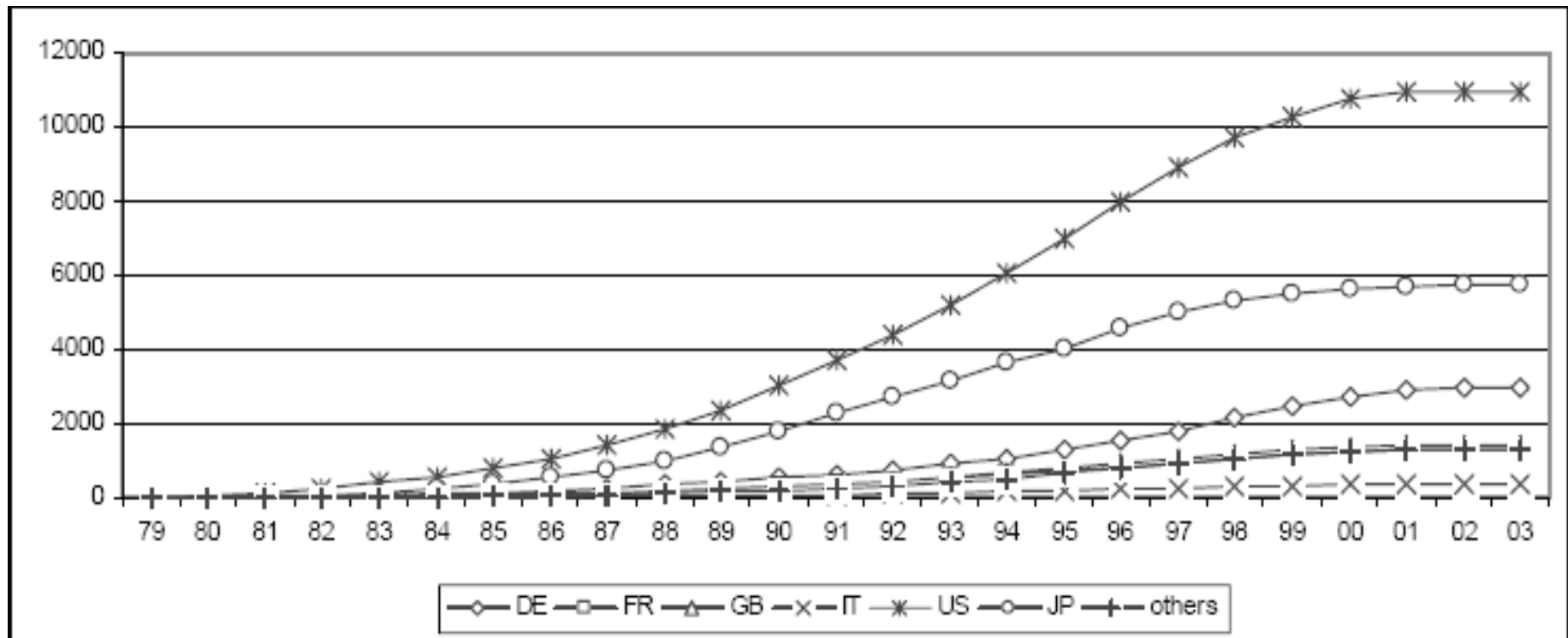
Thanks!



Backup Slides



Investigation of Potential Home Country Bias: European Software Data



European Patent Office Software Patent Grants by Country of the Assignee and Year of Application

Source: Thoma and Torrisi (2006)