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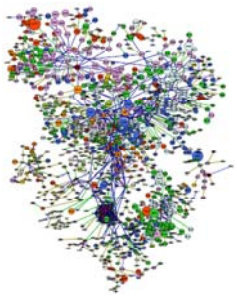


STRUCTURAL TRANSFORMATION IN CHILE

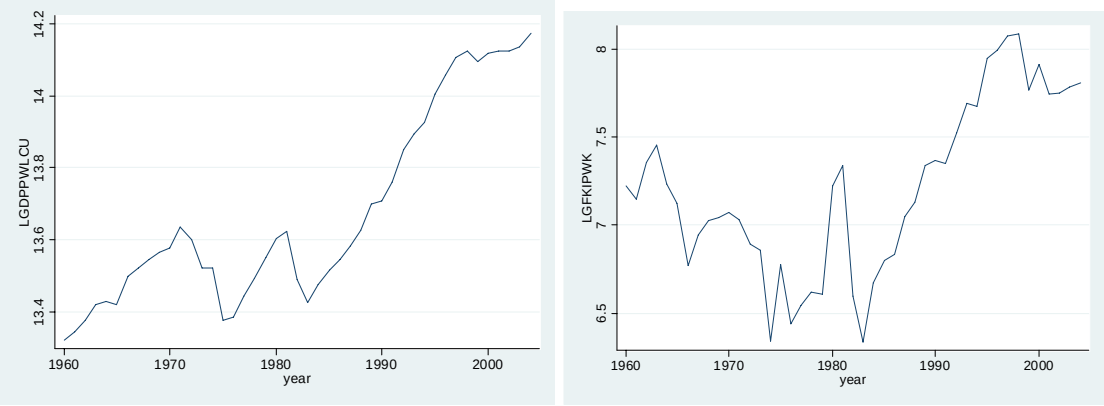
Ricardo Hausmann & Bailey Klinger

June 2007

Introduction

Chile's robust economic growth during Latin America's period of economic stagnation has earned it the reputation of an economic star. However, the impressive growth during the 1980s and 1990s seems to be cooling down. The following figure shows GDP per worker and investment per worker from 1960 to 2004, both of which level off in the late 1990s.

Figure 1
GDP per worker (left) and Investment per worker (right), 1960-2004, Chile



Source: WDI

This is despite booming exports on the back of high international prices. Might there be a fundamental problem behind Chile's economic performance? The purpose of this paper is to address this question by motivating and applying new analytic methods to study how the structure of production in Chile has evolved over the past 30 years, and what the country's prospects are for the future.

The main finding of this analysis is that Chile's pattern of specialization implies little opportunities for easy movements to new activities. Chile is specialized in an extremely sparse part of the product space and has a relatively unsophisticated export package. Past growth has been surprisingly strong given this pattern of specialization, as has been performance in the services sector, and it appears that there does remain some room to continue growing through quality upgrading in existing products. However, Chile has little room to increase its market share in existing products, and its current export package does not offer a path to future structural transformation and growth. Furthermore, this isn't due to Chile's status as a natural resource-based economy, as the country lags in these dimensions even when compared to countries like Canada, Australia, and New Zealand. Movements to new sectors are necessary, but will be difficult given this pattern of specialization. This suggests that there should be some scope for public investment in the study and coordination of new export activities to fuel long-term economic growth.

Examining Chile's Export Basket

New research shows that the composition of a country's export basket has important consequences. Hausmann, Hwang and Rodrik (2006) find that is not only how much, but also what you export that matters. Countries with more 'sophisticated' export baskets enjoy faster subsequent growth.

The level of 'sophistication' of exports is indirectly measured by examining the wages of those countries producing them. This metric is constructed as follows: the authors develop a measure of the revealed sophistication for each product, which they call PRODY, as the revealed comparative advantage (RCA)-weighted GDP per capita of each country that exports the good:

$$PRODY_{i,t} = \sum_{c} \frac{\left(xval_{i,c,t} / X_c\right)}{\sum_{j}\left(xval_{i,c,t} / X_c\right)} Y_c$$

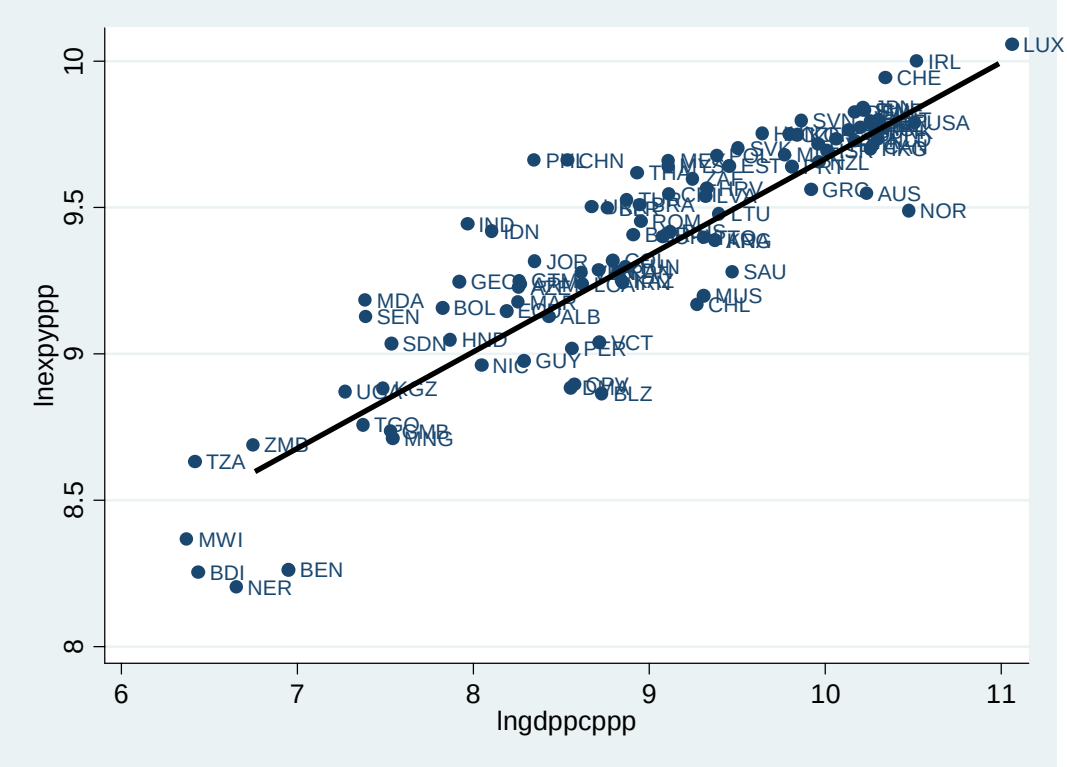
where $xval_{i,c,t}$ equals exports of good i by country c in year t, X_c equals total exports by country c, and Y_c equals GDP per capita of country c. This is a measure of the GDP per capita of the 'typcial' country that exports product i. Richer-country goods are more 'sophisticated', and are associated with higher wages. It is important to keep in mind tha this is a measure of sophistication that is inferred from the types of countries exporting a good—it is not measuring sophistication directly.

This product-level measure of sophistication can then be used to measure the sophistication of a country's entire export basket as a whole. The authors call is measure EXPY. EXPY is simply the PRODY of each good (i) that the country c exports, weighted by that good's share in the country's export basket (X_c). It represents the income level associated with a country's export package.

$$EXPY_{c,t} = \sum_{i}\left(\frac{xval_{c,i,t}}{X_{c,t}}\right) PRODY_{i,t}$$

Not surprisingly, the level of income implied by a country's export basket (EXPY) rises is correlated with actual income. That is, rich countries produce rich country goods, as illustrated below.

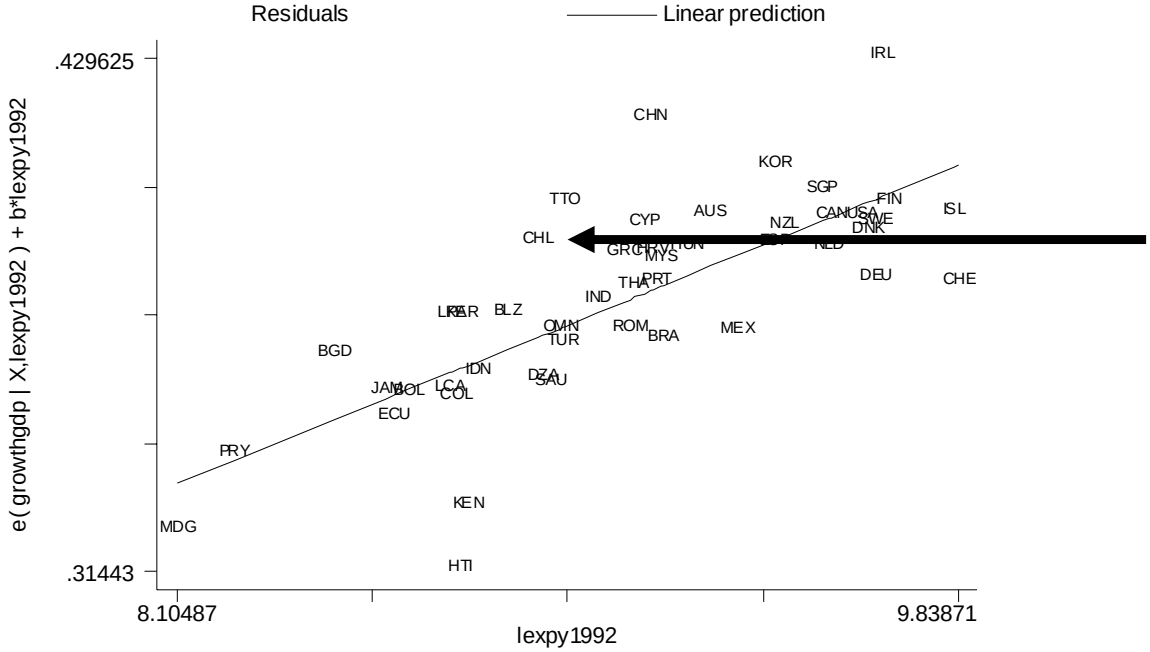
Figure 2
Export Sophistication & GDP per capita, 2004



The x-axis is real GDP per capita (PPP) in logs, and the y-axis is EXPY (PPP) in logs. Source: Author's calculations

However, there is significant variance in this relationship. Some countries have managed to discover products that are associated with a level of income much higher than their own, such as China, India, Indonesia, the Philippines, Mexico, and Ireland. Moreover, this variance has important consequences: the authors find that countries converge to the income level implied by their export basket. In essence, countries become what they export. This means that if a country has managed to begin exporting a sophisticated export basket relative to its income level, subsequent growth is higher as GDP converges to that level. However, countries specialized in relatively unsophisticated export baskets suffer lagging economic performance. Put another way, the payoff of exporting more of the same depends on export current sophistication. The figure below shows the level of export sophistication (on the x-axis) versus subsequent GDP growth, with a line fitted to the expected level of growth given export sophistication. This line is upward-sloping: higher export sophistication, controlling for GDP per capita, is associated with higher growth.

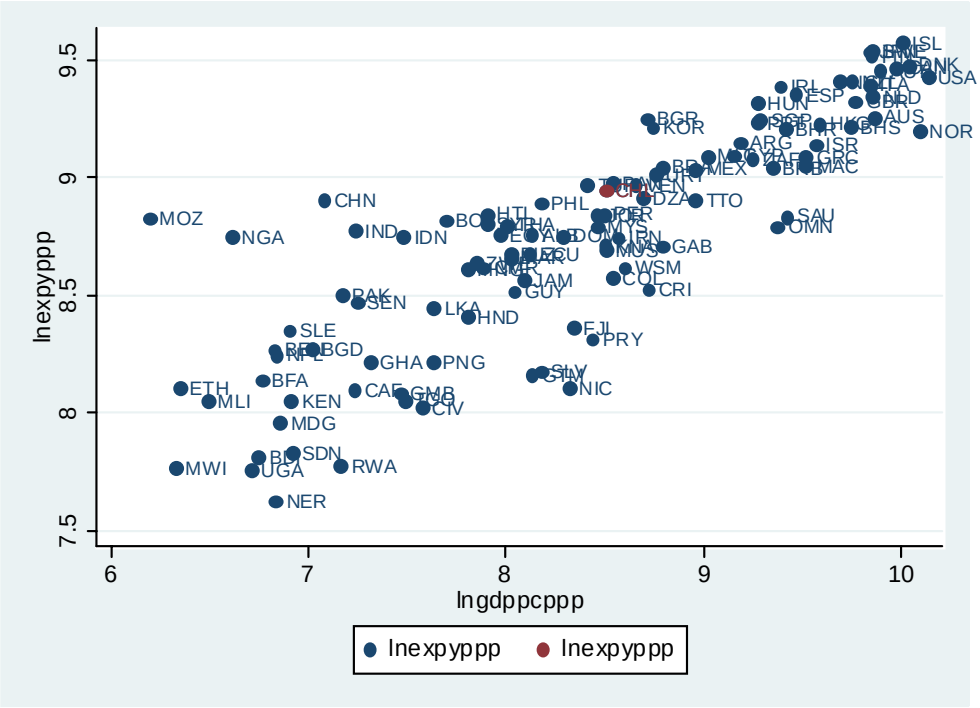
Figure 3
Export sophistication and Subsequent Growth



The x-axis is the log of initial EXPY, and the y-axis is subsequent GDP growth. The linear prediction is expected growth of GDP per capita given initial EXPY. Source: Hausmann Hwang & Rodrik 2006.

How does Chile fare in this dimension? We can see from the figure above that Chile is above the regression line, meaning that economic growth was surprisingly fast given the country's level of EXPY and GDP per capita. This suggests a low EXPY. But this hasn't always been the case. The figure below shows EXPY vs. GDP per capita in 1985, which Chile shown in red.

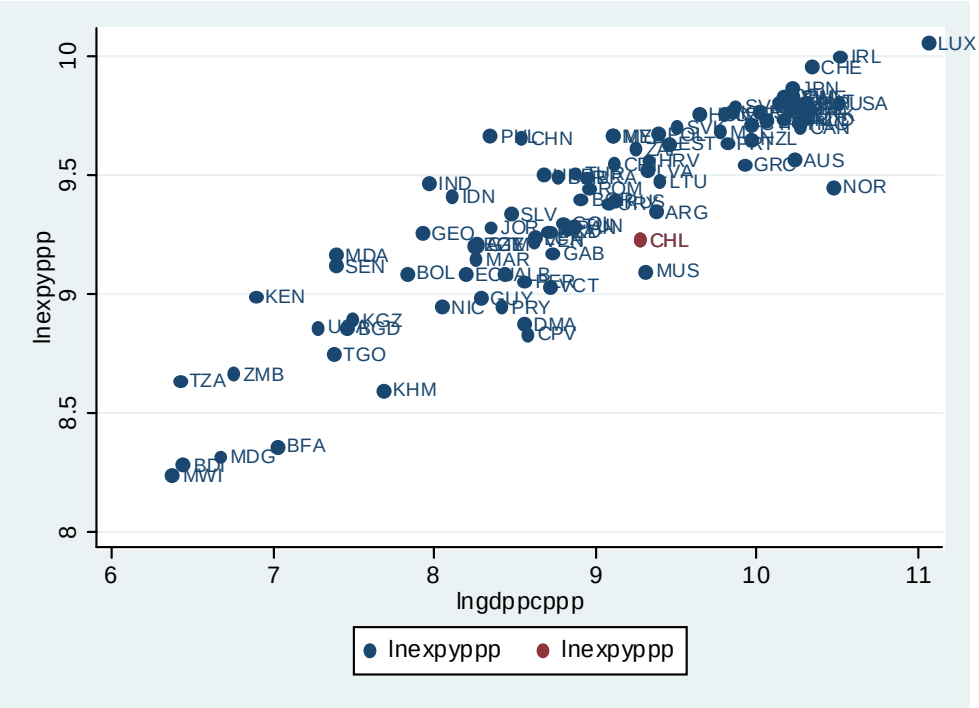
Figure 4
GDP per capita vs EXPY (PPP, logs). 1985



Source: Author's calculations using UN COMTRADE

Given its level of income, Chile had a relatively sophisticated export basket. However, more recent data shows that the country has fallen behind. Within its income band, Chile ranks as one of the lowest countries in the world in terms of export sophistication. Chile's export basket is typical of a poor country, not a rich country.

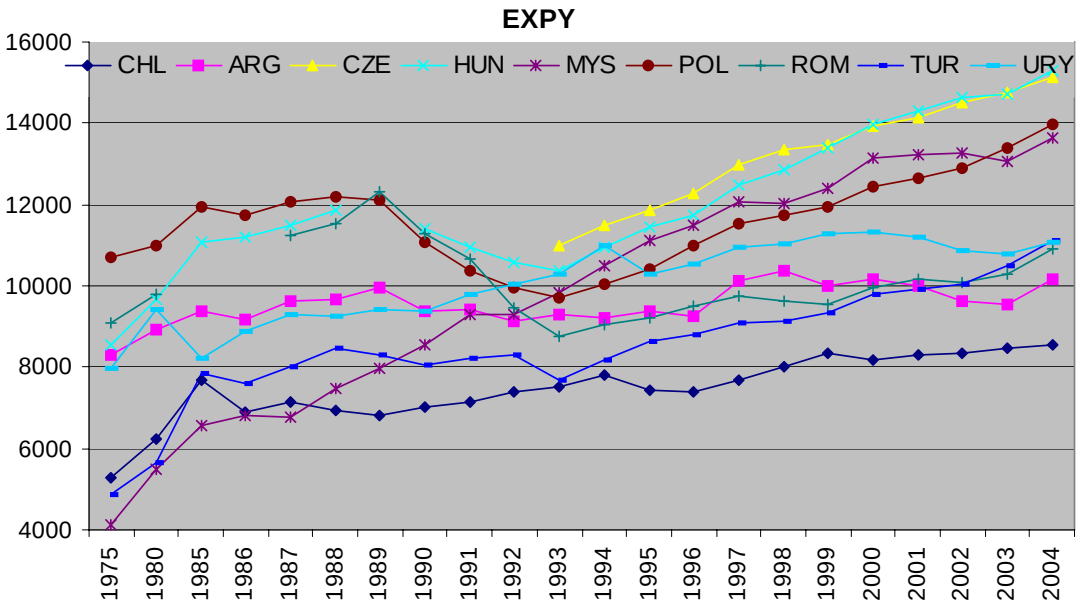
Figure 5
GDP per capita vs EXPY (PPP, logs). 2004



Source: Author's calculations using UN COMTRADE

How has this evolution of EXPY over time compare to other countries? The figure below shows EXPY over time for Chile and a group of comparator countries.

Figure 6
EXPY (PPP) Over Time, Comparative



Source: Author's calculations using Feenstra (2004) & UN COMTRADE

Chile has the lowest EXPY among this group, and in relative terms has fallen behind. Although it started 1975 with the same EXPY as Malaysia, the current value is barely 2/3rds that of Malaysia.

What are the products in Chile's export basket pulling up EXPY? These are shown in the following table.

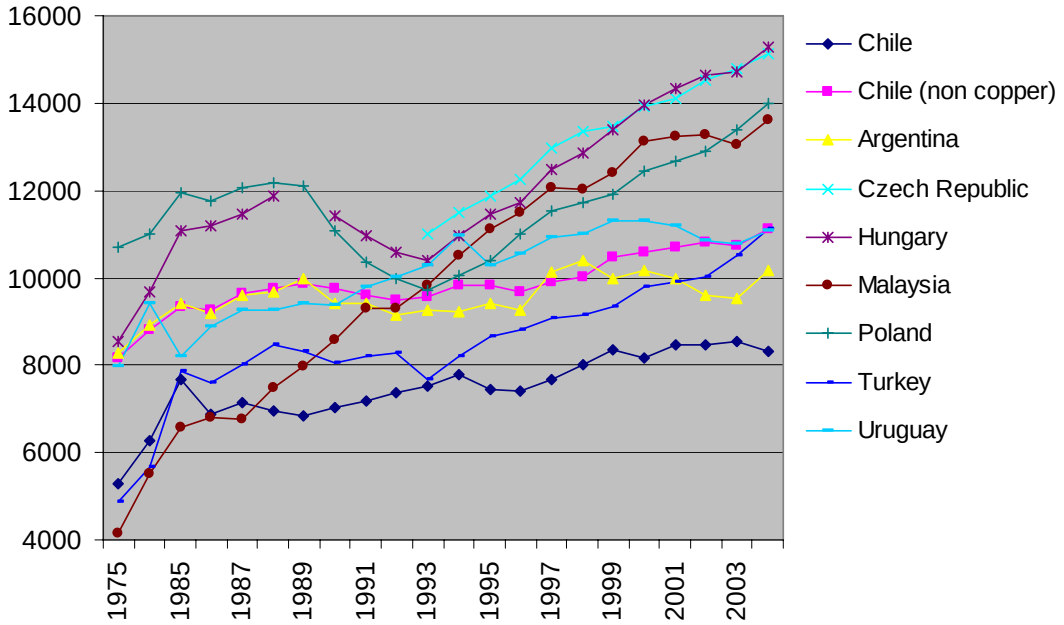
Table 1
Top EXPY Contributors, 2004

Product	PRODY (ppp)	Exports (US M)
Chemical wood pulp, soda or sulphat	17050	1212
Meat of swine, fresh, chilled or fr	23580	235
Flours, etc, of meat, fish, etc, un	15610	344
Fibreboard of wood or other ligneou	19161	230
Paper..., coated with kaolin (china	23570	136
Crustaceans... and other aquatic in	21056	132
Newsprint, in rolls or sheets	20758	118
Fish,salted,dried...;smoked fish;fi	23597	73
Food preparations not elsewhere spe	15962	98
Ash and residues containing metals	17548	74

Goods with PRODY>1.5*EXPY, sorted by overall contribution to EXPY. Source: Author's calculations using UN COMTRADE

The formula above shows that EXPY is constructed with weights for each good taken from their share of total exports. Chile's export basket is dominated by copper exports: A relatively unsophisticated product. If Chile's non-copper exports were highly sophisticated, this could be hidden behind copper's dominant share in total exports, making EXPY deceivingly small. To allow for this possibility, we eliminate copper from the export basket and calculate EXPY according to the formula. This provides Chile's non-copper EXPY, which is shown in the following figure.

Figure 7
EXPY over time, Comparative, Including Non-Copper Chile

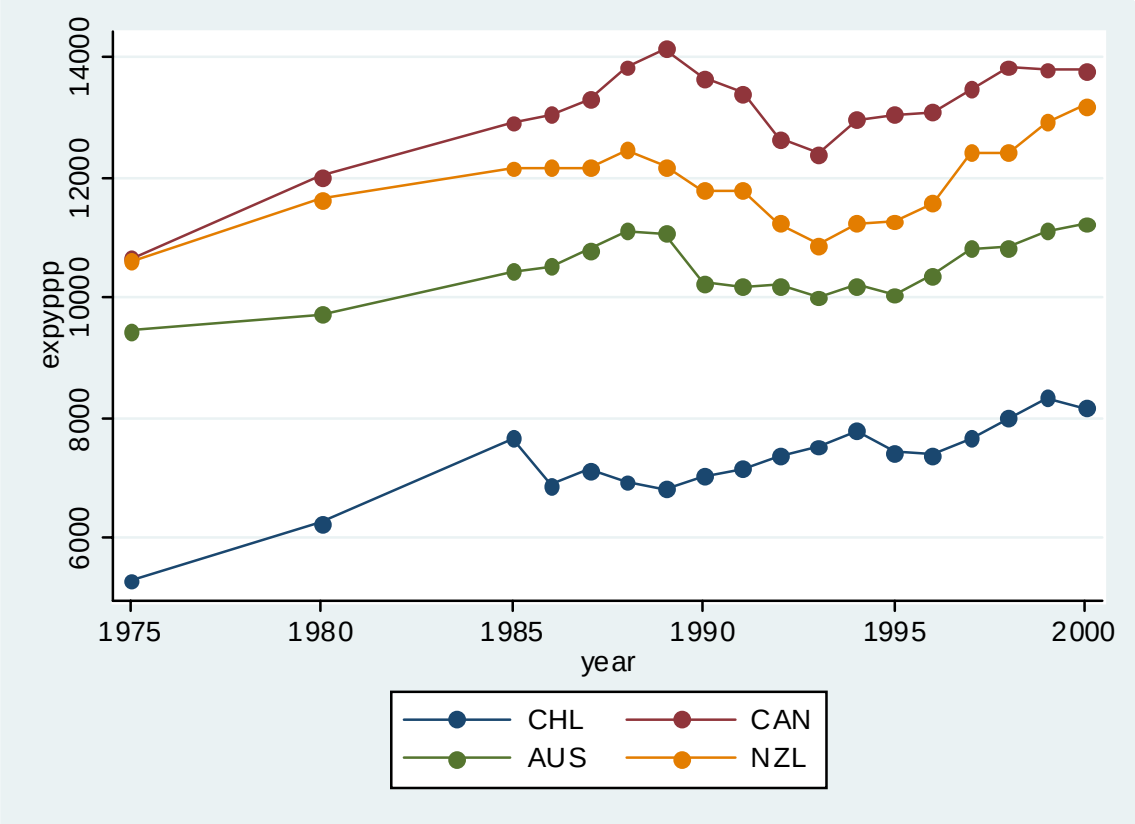


Source: Author's Calculations using UN COMTRADE

This figure shows that excluding copper from the export basket has a level effect, with the pink line shifting parallel from the original EXPY line (blue). However, even the non-copper export basket has a comparatively low EXPY. More worryingly, eliminating copper does not affect the trend: Chile's non-copper export sophistication is falling behind. It has been surpassed by Turkey, which began 1975 with an EXPY barely half of that of Chile (non-copper). Chile's non-copper export basket had the same level of export sophistication as Hungary in 1975, but as of 2004 was barely more than 2/3rds that of Hungary. Copper is not to blame for Chile's low and stagnant EXPY.

Maybe these are not the right comparators. Chile, as an advanced agriculture and natural resource exporter may be better compared to countries like New Zealand, Canada and Australia rather than industrially-focused countries like Turkey. The figure below shows EXPY in Chile compared to these advanced natural-resource exporters.

Figure 8
EXPY (PPP) over time, Comparative



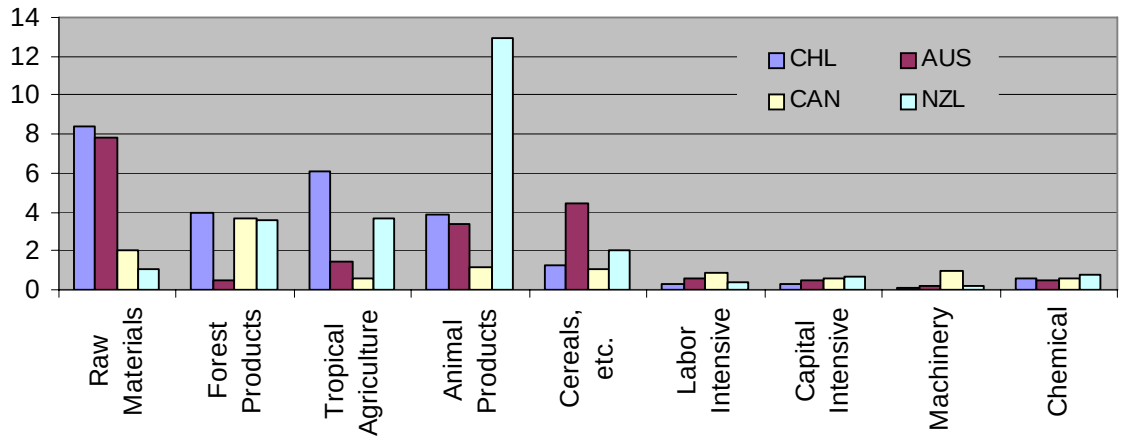
Source: Author's calculations using UN COMTRADE.

In this comparison, Chile is clearly lower in terms of export sophistication, although the trend is not as bad. Nevertheless, Chile is not catching up. How does Chile's structure of production as represented in exports compare to these countries? We consider this question by examining the country's RCA index in different sectors. RCA is calculated according to the Balassa (1965) definition:

$$RCA_{c,i,t} = \frac{xval_{c,i,t} \Big/ \sum_{i} xval_{c,i,t}}{\sum_{c} xval_{c,i,t} \Big/ \sum_{i}\sum_{c} xval_{c,i,t}}$$

Where xval is the value of exports for country c in good/sector i in year t. We first consider patterns of specialization across Leamer's commodity groups (Leamer 1984). These are shown below for Chile, Canada, Australia, and New Zealand.

Figure 9
RCA by Leamer Commodity Group, 1999



Source: Author's calculations using UN COMTRADE

Chile is clearly much more specialized in raw materials, forestry, and agriculture than these advanced natural-resource exporters. And as can be seen below, the country is lagging in manufactured goods, which tend to be more sophisticated and pay higher wages.

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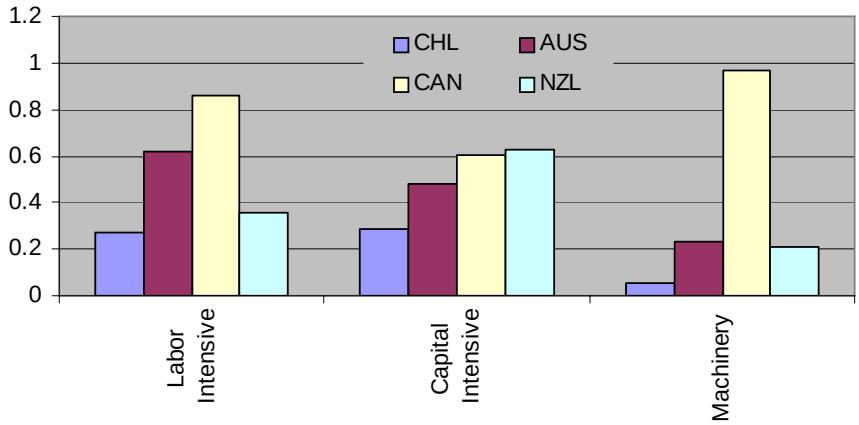
Figure 10
RCA by Leamer Category (Subset of major manufacturing sectors)



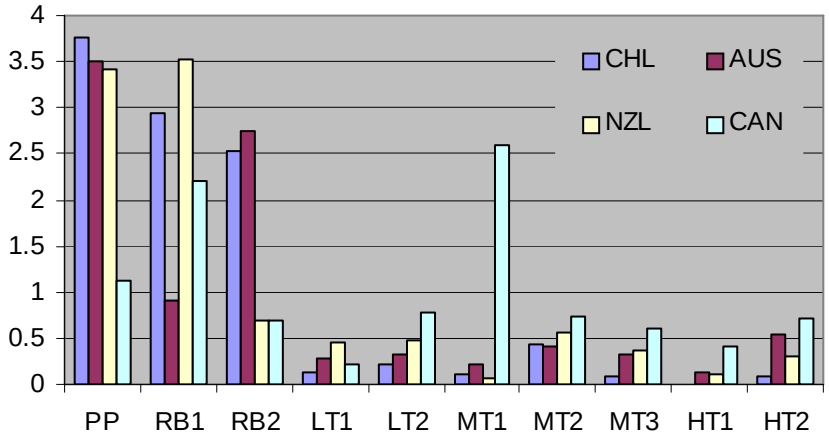
Source: Author's calculations using UN COMTRADE

In addition to Leamer's groupings, a more recent classification is that of Lall (2000), based on technological sophistication, which has the following categories:

PP	Primary Products
RB1	Resource-Based Products (agriculture)
RB2	Resource-Based Products (other)
LT1	Low-Technology (textile, garment, footwear)
LT2	Low-Technology (other)
MT1	Medium-Technology (automotive products)
MT2	Medium-Technology (chemicals & basic metals)
MT3	Medium-Technology (engineering products)
HT1	High-Technology (electronics)
HT2	High-Technology (other)

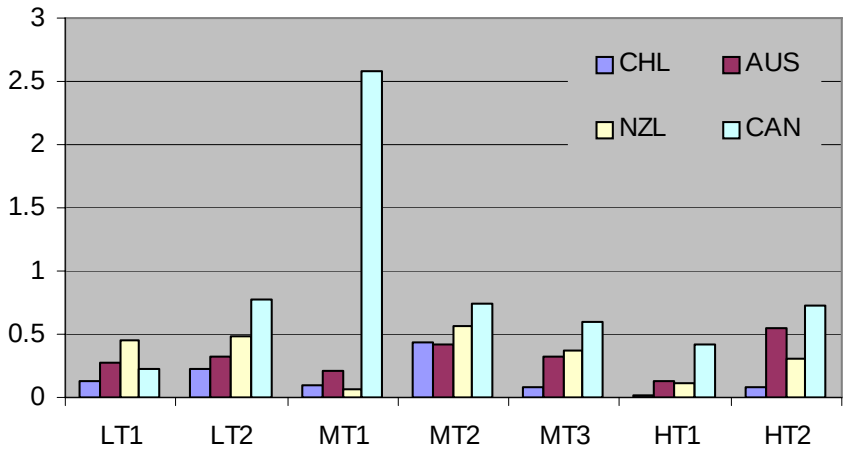
A comparison of RCA by Lall sector is provided below.

Figure 11
RCA by Lall Category, 1999



Source: Author's calculations using UN COMTRADE

Figure 12
RCA by Lall Category (non-resource based categories), 1999



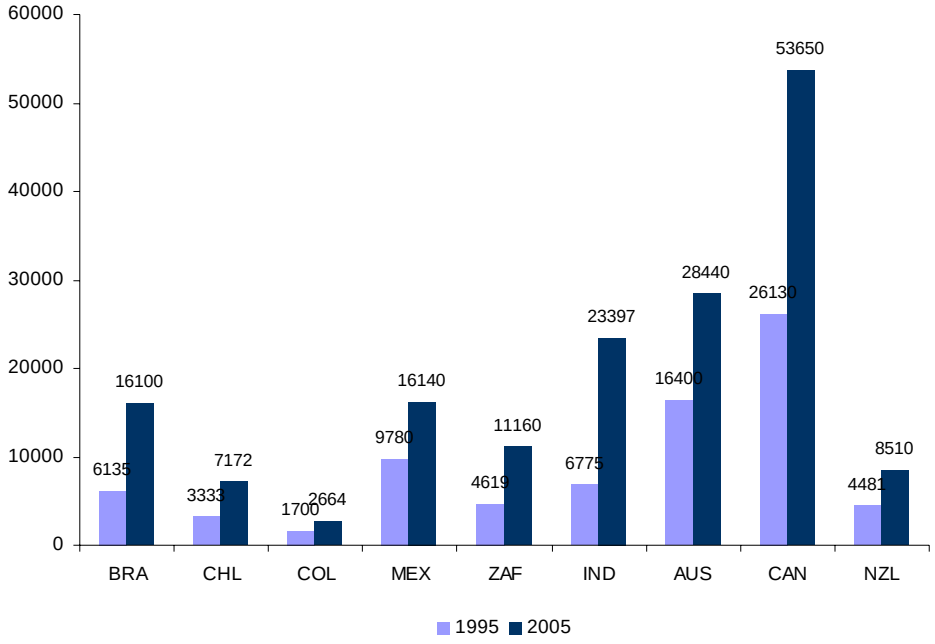
Source: Author's calculations using UN COMTRADE

Again, we see that Chile is highly specialized in primary products. Moreover, it is highly under-specialized in all categories of non-resource based exports, which tend to be more sophisticated and pay higher wages. This is particularly true of the higher-technology product categories. And remember, this is compared to the world's successful natural resource-concentrated countries. So Chile's poor relative EXPY can't be blamed on its belonging to a different class of advanced natural-resource based economies. We now consider Chile's exports of services.

Services

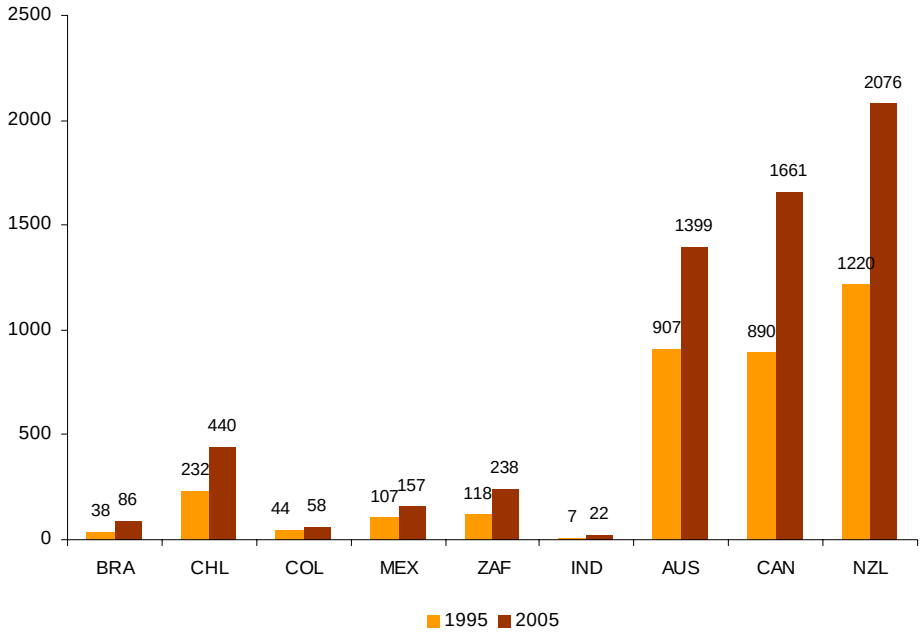
Just as including copper may be biasing Chile's EXPY standing, perhaps excluding services is biasing the results. It could be that EXPY is lagging for Chile simply because it is concentrating in services, which are not captured in our calculations of EXPY. The following figures show Chile's worldwide service exports, both totals and in per capita terms.

Figure 13
Total Worldwide Service Exports



Source: Author's calculations using WDI

Figure 14
Total Worldwide Service Exports per Capita



Exports in 2000 dollars per thousand population. Source: Author's calculations using WDI

Indeed, Chile is a major service exporter. In per capita terms, service exports almost doubled between 1995 and 2005, and Chile's exports are significantly higher than its Latin American neighbors. However, these exports pale in comparison to the advanced natural resource exporters. Unfortunately, data limitations do not allow us to consider services more systematically.

We now turn to another potential explanation for the lack of structural transformation and upgrading of the export package in Chile: the country's area of specialization in the product space.

Structural Transformation in the Product Space

Hausmann & Klinger (2006 & 2007) investigate the process of structural transformation and find that this process is easier when moving to 'nearby' products. This is based on the idea that every product involves highly specific inputs such as knowledge, physical assets, intermediate inputs, labor training requirements, infrastructure needs, property rights, regulatory requirements or other public goods. These inputs are specific in the sense that the requirements are very different for different sectors. Established industries somehow have sorted out the many potential failures involved in assuring the presence of all of these inputs, which are then available to subsequent entrants in the industry. But firms that venture into new products will find it much harder to secure the requisite inputs. For example, they will not find workers with experience in the product in question or suppliers who regularly furnish that industry. Specific infrastructure needs such as cold storage transportation systems may be non-existent, regulatory services such as product

approval and phyto-sanitary permits may be underprovided, research and development capabilities related to that industry may not be there, and so on.

These firms moving to new activities will therefore have to adapt whatever capabilities exist. We find evidence supporting the view that the assets and capabilities needed to produce one good are imperfect substitutes for those needed to produce another good, but this degree of asset specificity will vary. Correspondingly, the probability that a country will develop the capability to be good at producing a particular new good is related to its installed capability in the production of other similar, or nearby goods for which the currently existing productive capabilities can be easily adapted. The barriers preventing the emergence of new export activities are less binding for nearby products which only require slight adaptations of existing capacity.

This is found by first developing a measure of distance between products. We measure the distance between each pair of products based on the probability that countries in the world export both. If two goods need the same capabilities, this should show up in a higher probability of a country having comparative advantage in both. Formally, the inverse measure of distance between goods *i* and *j* in year *t*, which we will call proximity, equals

$$\varphi_{i,j,t} = \min\left\{P\left(x_{i,t} \mid x_{j,t}\right), P\left(x_{j,t} \mid x_{i,t}\right)\right\}$$

where for any country *c*

$$x_{i,c,t} = \begin{cases} 1 & if \quad RCA_{i,c,t} > 1 \\ 0 & otherwise \end{cases}$$

and where the conditional probability is calculated using all countries in year *t*. This is calculated using disaggregated export data across a large sample of countries from the World Trade Flows data from Feenstra et. al. (2005) and UN COMTRADE.

The heterogeneity of the product space can be shown econometrically, yet it is also revealing to illustrate these pairwise distances graphically. Using the tools of network analysis, we can construct an image of the product space (Hidalgo et al. forthcoming).

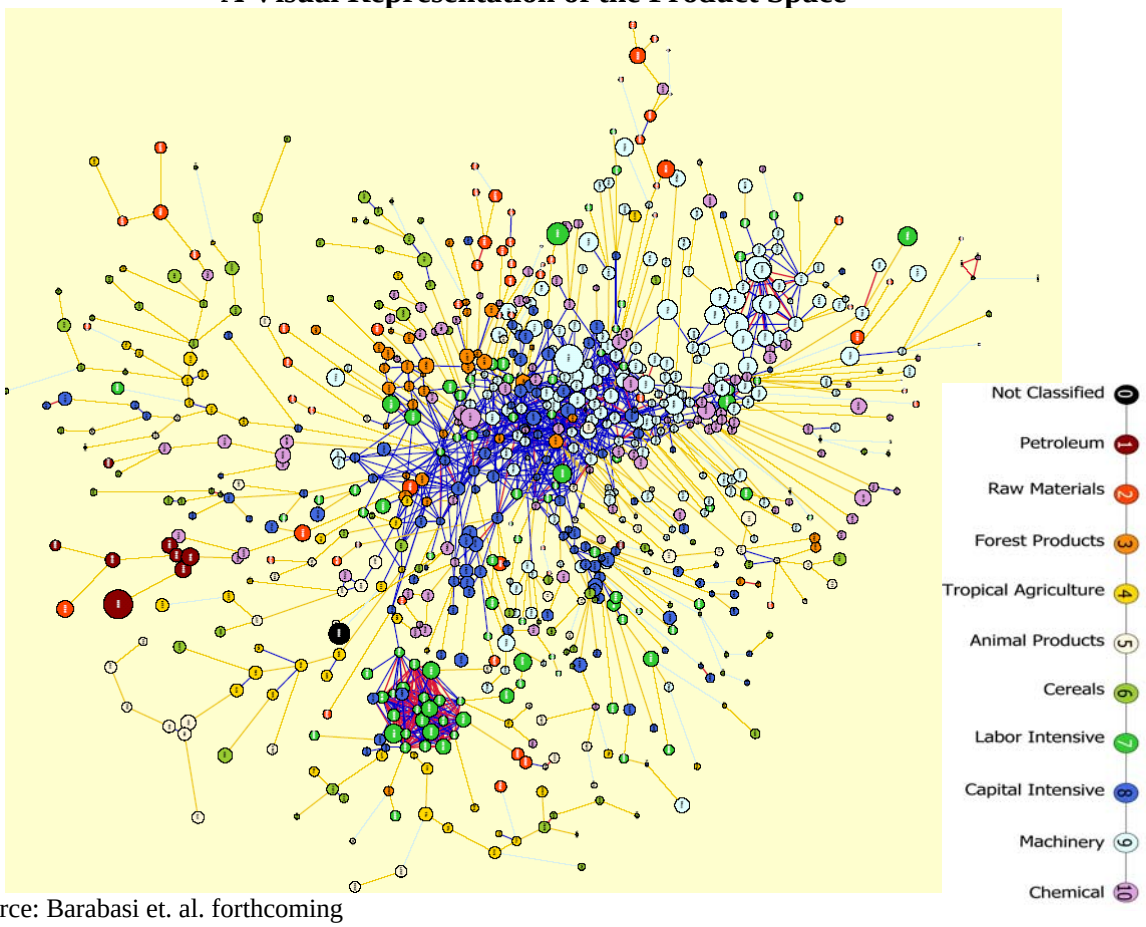
Considering the linkages as measured in the 1998-2000 period, we first create the maximum spanning tree by taking the one strongest connection for each product that allows it to be connected to the entire product space. This is shown below.

Figure 15
Maximum Spanning Tree

Source: Hidalgo et. al., forthcoming

The next step is to overlay this maximum spanning tree with the stronger links, and color-code the linkages between products depending on their proximity. In the Figure below, we show the visual representation of the product space. Each node is a product, its size determined by its share of world trade. In these graphs, physical distances between products are meaningless: proximity is shown by color-coding the linkages between pairs of products. A light-blue link indicates a proximity of under .4, a beige link a proximity between .4 and .55, a dark-blue link a proximity between .55 and .65, and a red link a proximity greater than .65. Links below 0.55 are only shown if they make up the maximum spanning tree, and the products are color-coded based on their Leamer (1984) commodity group.

Figure 16
A Visual Representation of the Product Space



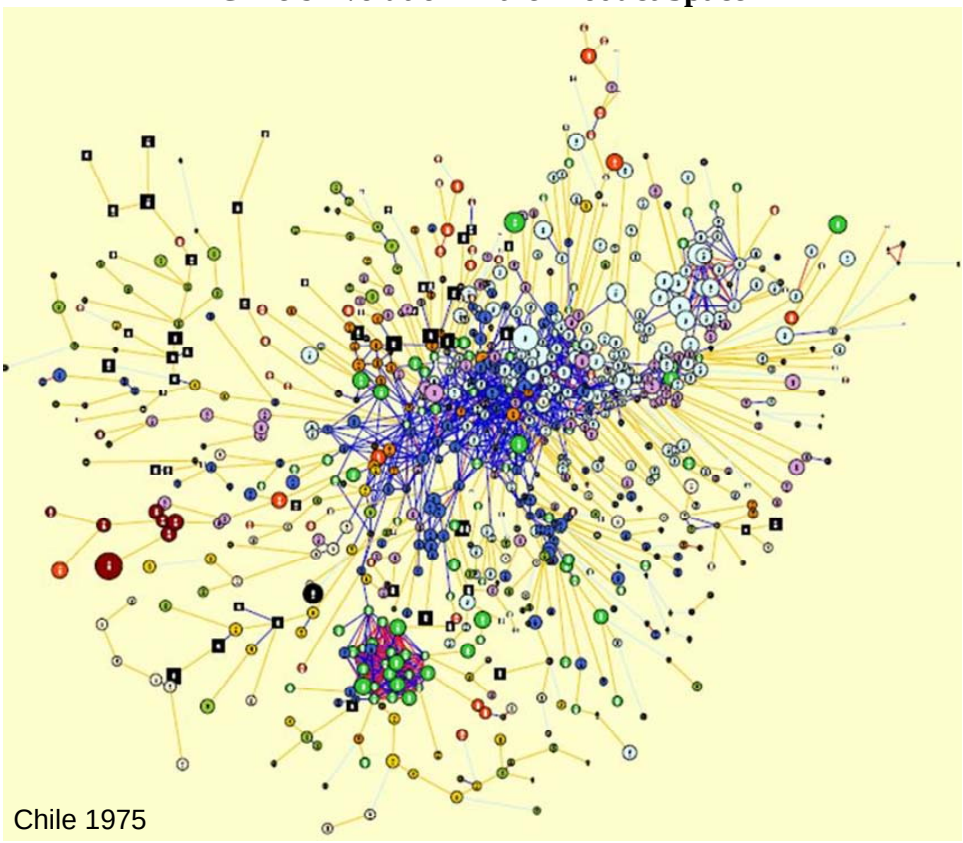
Source: Barabasi et. al. forthcoming

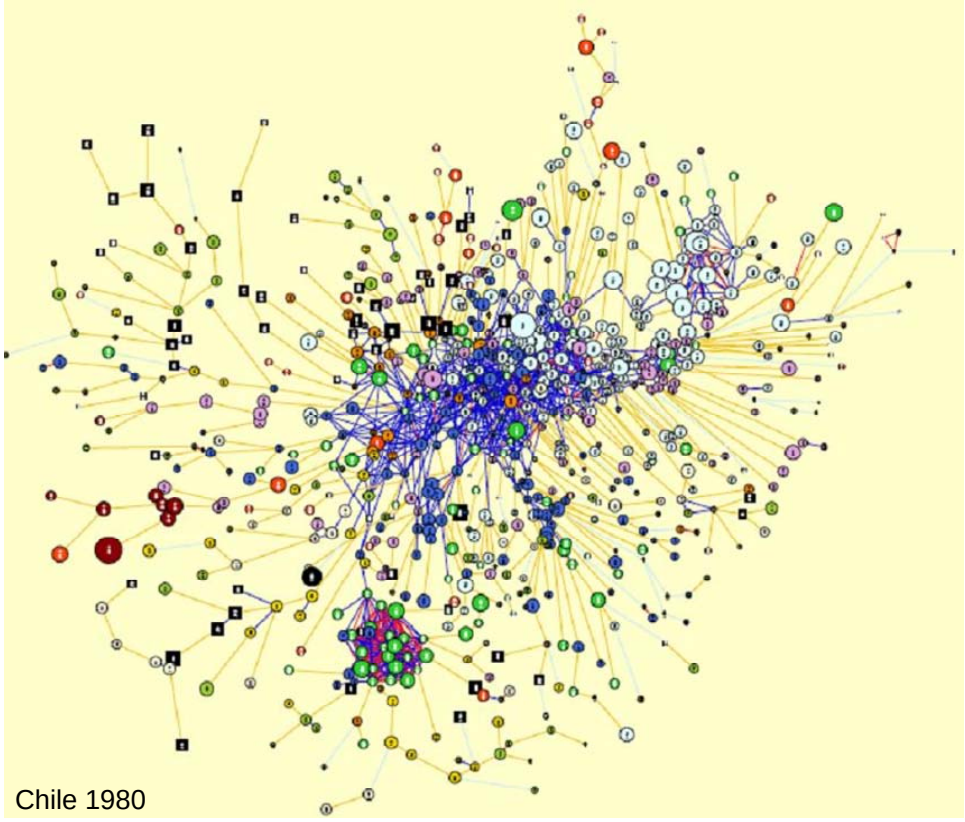
We can immediately see from the figure above that the product space is highly heterogeneous. There are peripheral products that are only weakly connected to other products. There are some groupings among these peripheral goods, such as petroleum products (the large red nodes on the left side of the network), seafood products (below petroleum products), garments (the very dense cluster at the bottom of the network), and raw materials (the upper left to upper periphery). Furthermore, there is a core of closely connected products in the center of the network, mainly of machinery and other capital intensive goods.

This heterogeneous structure of the product space has important implications for structural transformation. If a country is producing goods in a dense part of the product space, then the process of structural transformation is much easier because the set of acquired capabilities can be easily re-deployed to other nearby products. However, if a country is specialized in peripheral products, then this redeployment is more challenging as there is not a set of products requiring similar capabilities. The process of structural transformation can be impeded due to a country's orientation in this space.

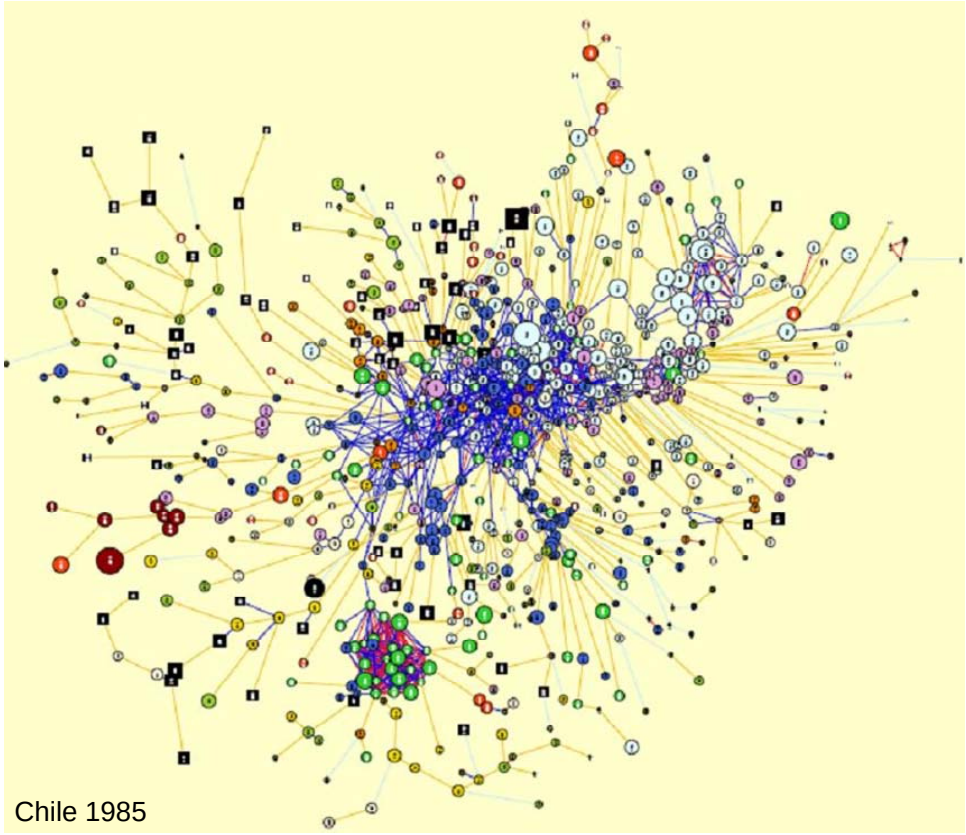
The figures below show Chile's evolution in this product space, where a black square on top of a product indicates that it is exported with comparative advantage.

Figure 17
Chile's Evolution in the Product Space

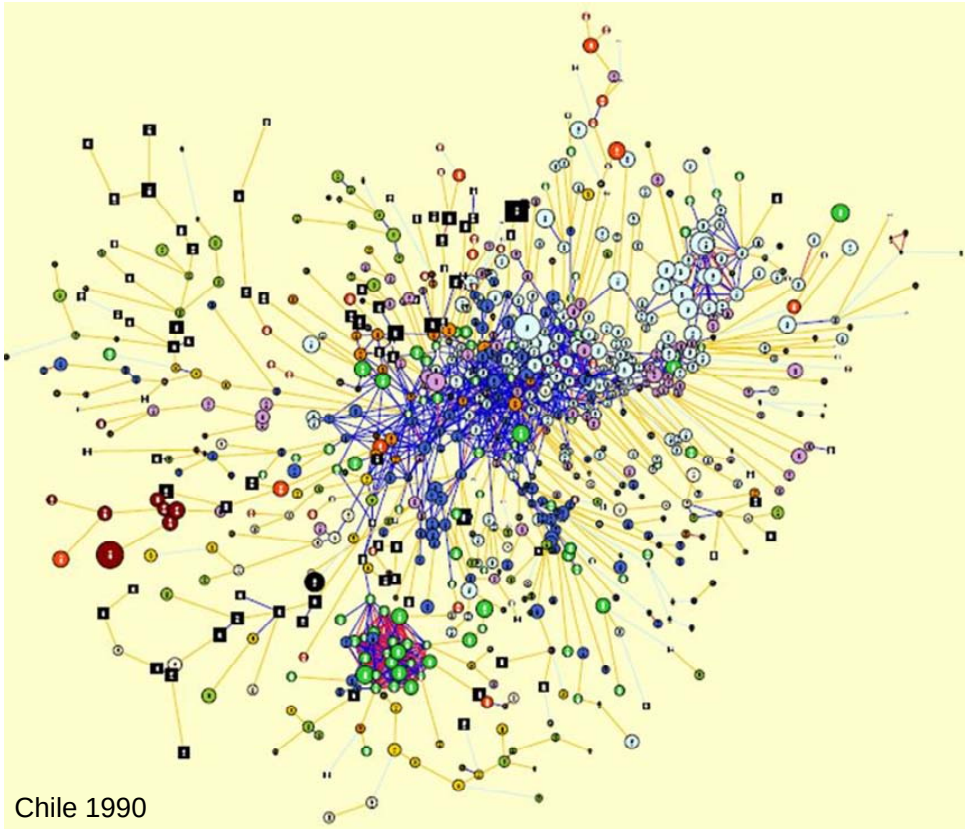




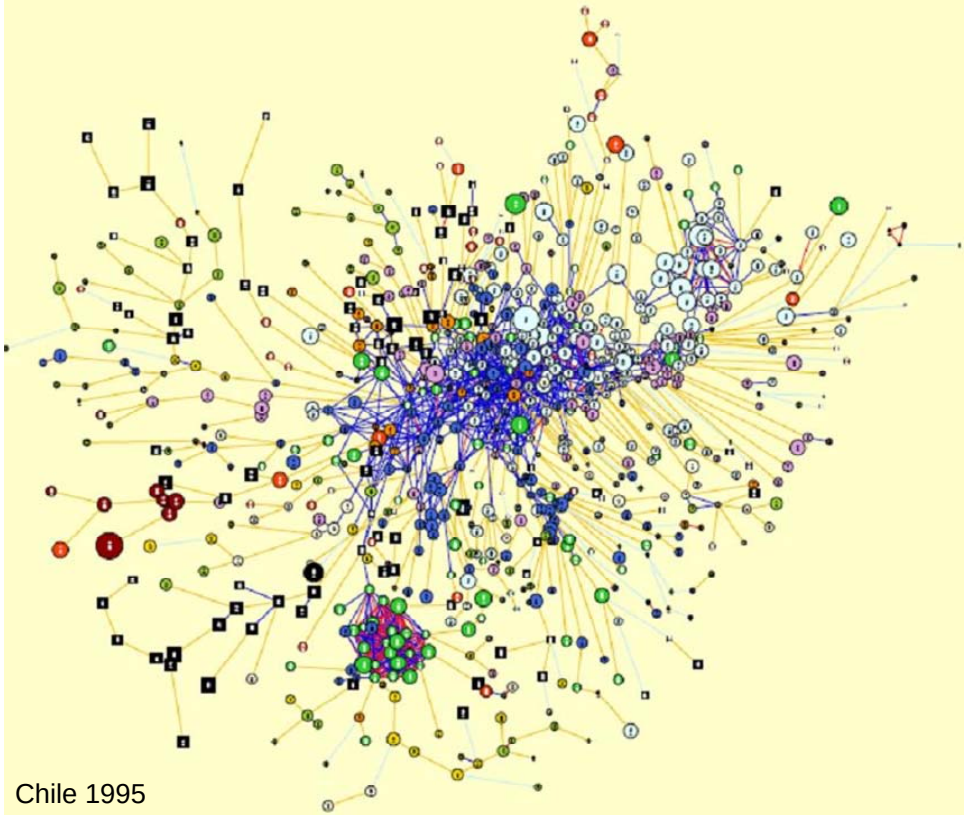
Chile 1980



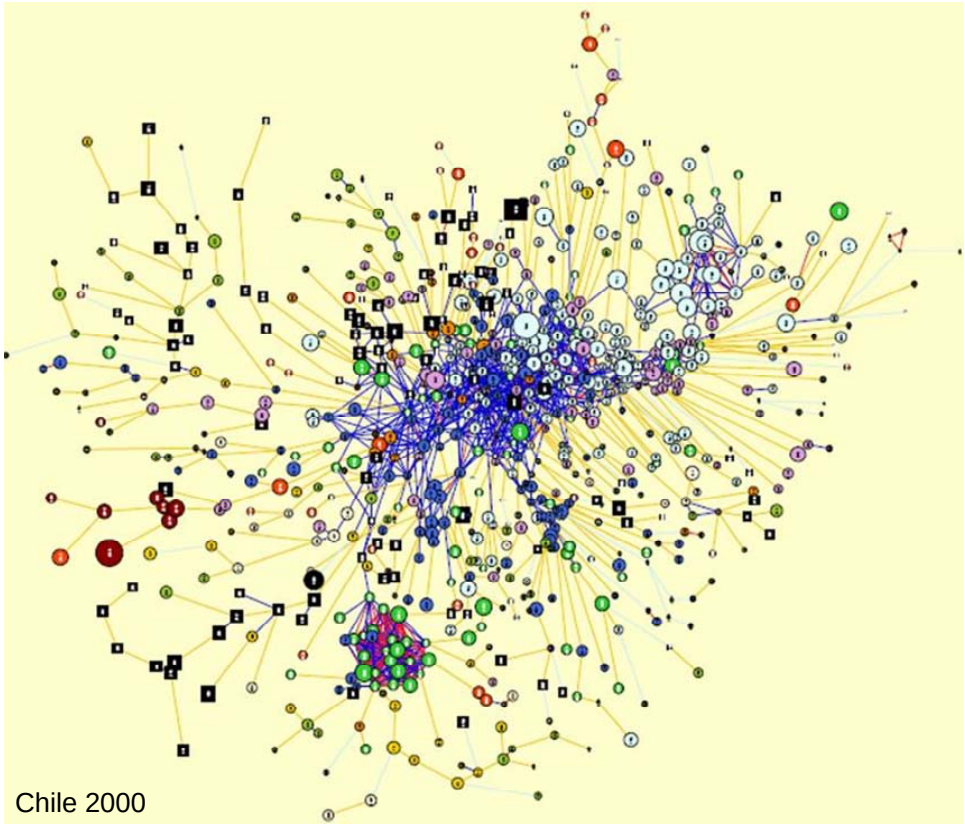
Chile 1985



Chile 1990



Chile 1995

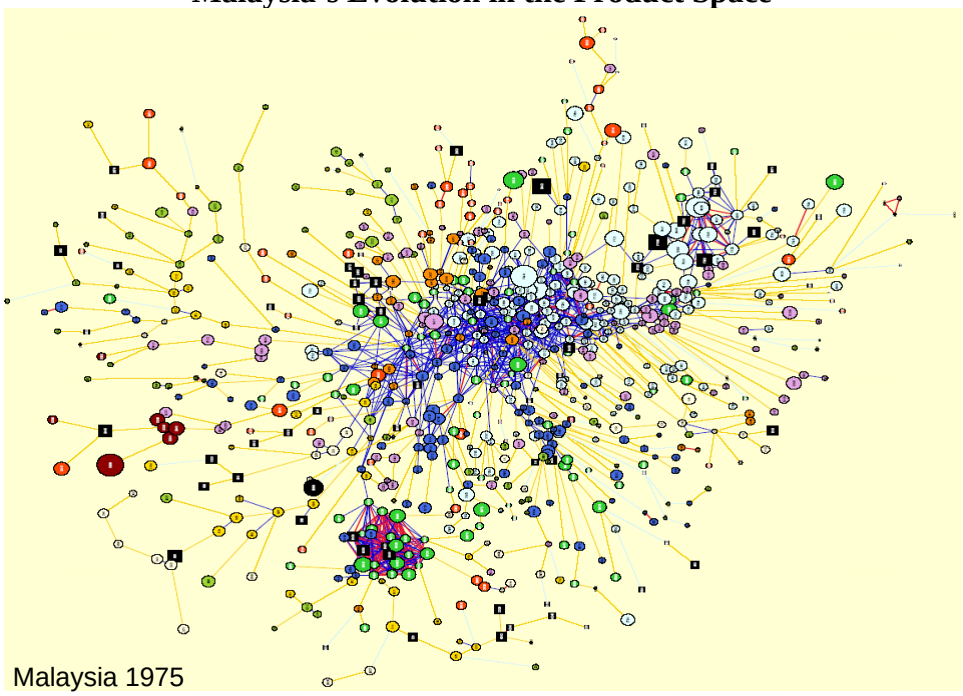


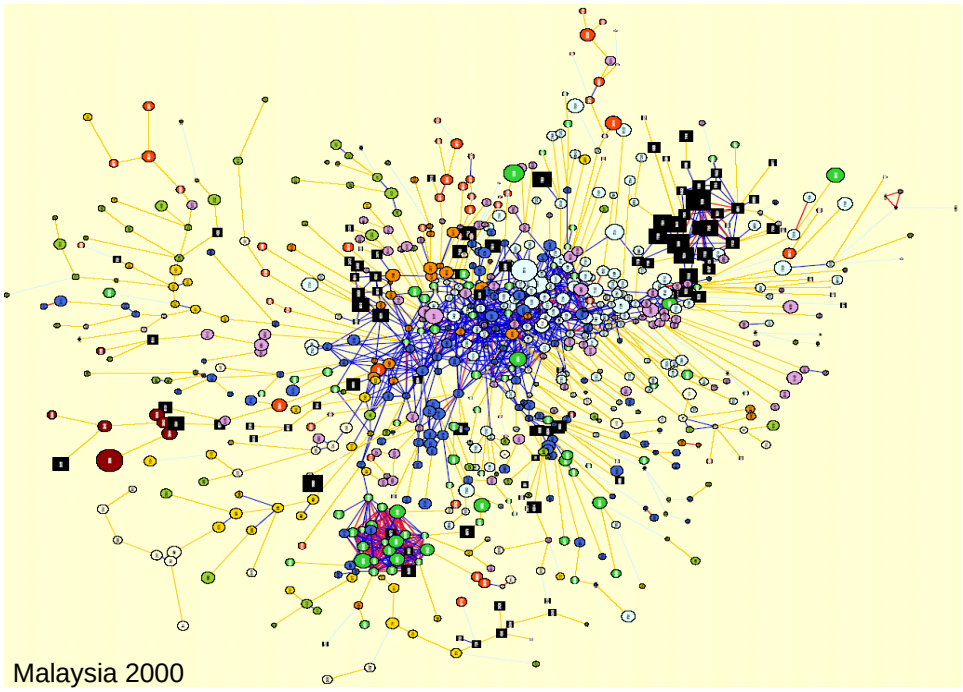
Source: Author's Calculations using UN COMTRADE

This figure shows that Chile occupied a loose cluster of seafood products (lower-left) and wood products (upper middle) during this period. These clusters are now nearly fully occupied. But beyond these movements, there has been little change in Chile's orientation in the product space. It is specialized in mining and agricultural goods that are highly peripheral, with few nearby opportunities for future structural transformation.

Compare this figure with that for Malaysia, shown below.

Figure 18
Malaysia's Evolution in the Product Space

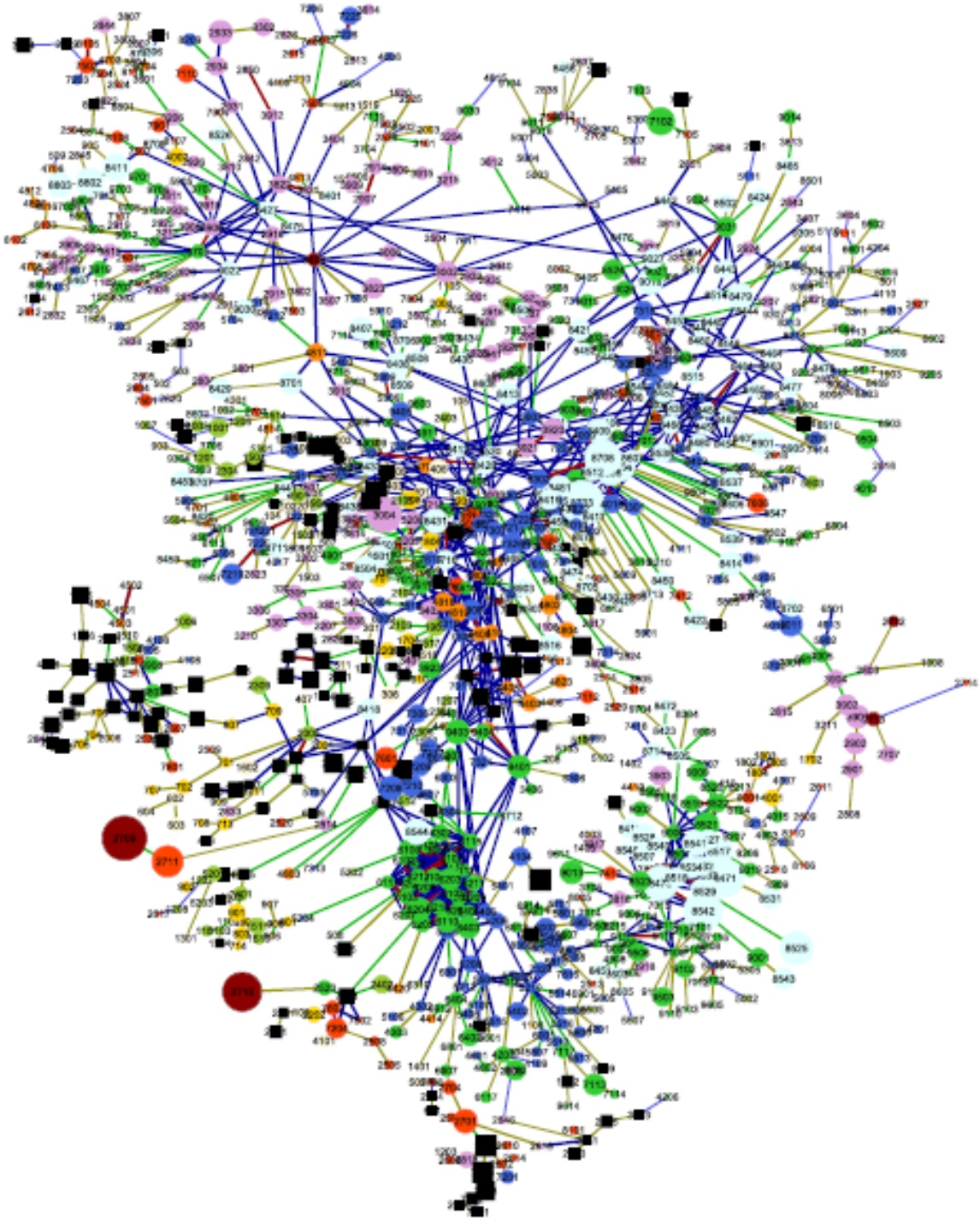




Source: Author's calculations using UN COMTRADE

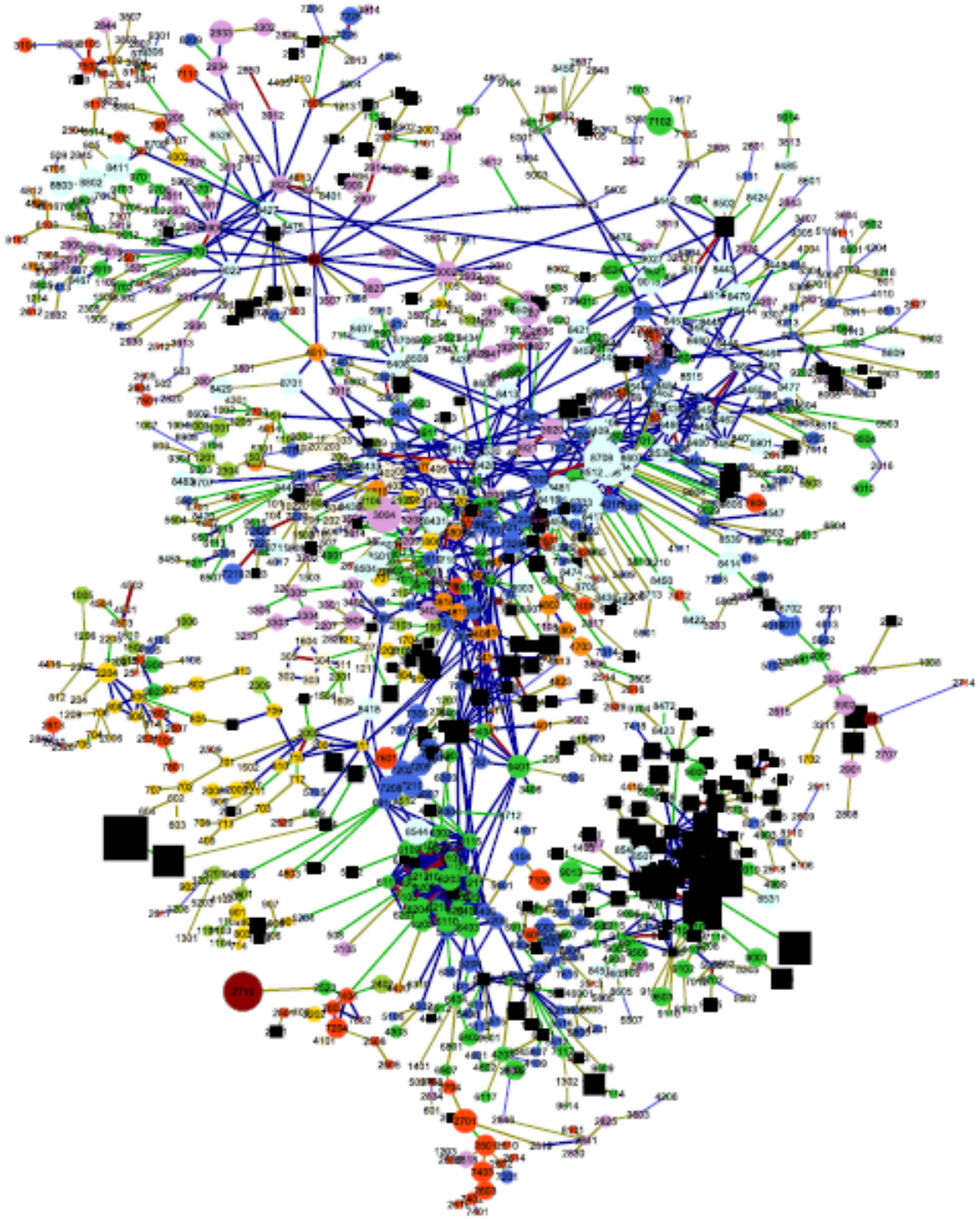
For analyzing movements in the product space subsequent to 2000, we move to an alternative classification system, with twice as many product codes, and graph it using the same methodology. Snapshots for 2005 are shown below for Chile, Malaysia, and Argentina.

Figure 19
Chile, 2005



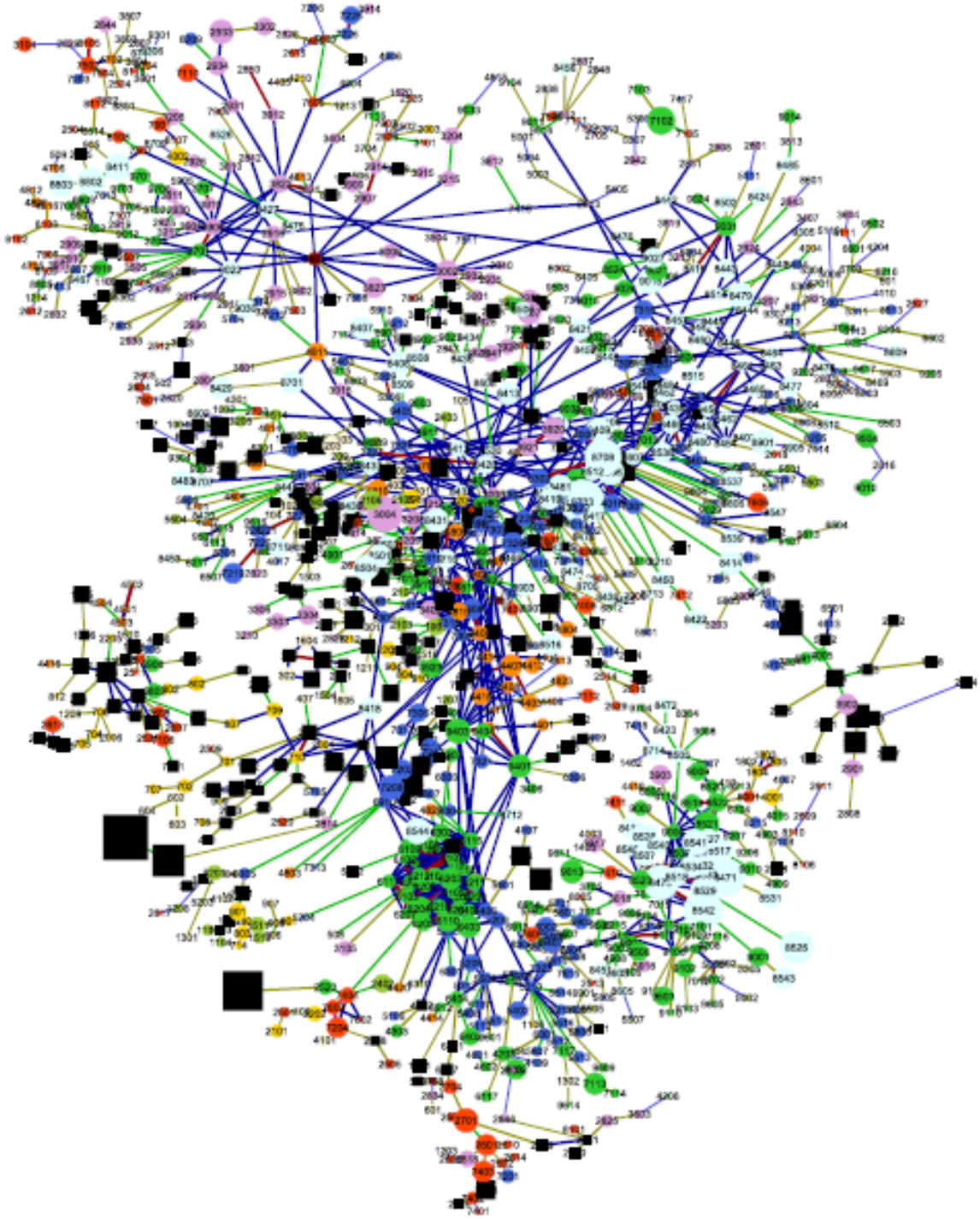
Source: Author's calculations using UN COMTRADE

Figure 20
Malaysia, 2005



Source: Author's calculations using UN COMTRADE

Figure 21
Argentina, 2005



Source: Author's calculations using UN COMTRADE

These figures show roughly the same picture: Chile is concentrated in a loosely-connected cluster of agricultural goods and natural resources, which are relatively disconnected from the product space. Moreover, these products are relatively small in terms of world market size (recall that the nodes and squares are proportionate to world

trade in that good). Finally, the loose clusters where Chile is present are almost completely occupied, meaning little room for future growth through jumping to nearby products. Malaysia, on the other hand, is specialized in a large cluster of electronics products, and Argentina has a very diffuse set of productive capabilities that imply many opportunities for future structural transformation, should other constraints to growth be addressed.

As can be seen in the figures between 1975 and 2000 both for Chile and Malaysia, black squares tend to emerge closer to other black squares, meaning structural transformation favors nearby products. This tendency is found to be quite strong in Hausmann & Klinger (2007), and it implies that Chile's opportunities for future structural transformation are governed by what is nearby.

To measure what is nearby, we must use the pairwise measures of distance defined above to calculate the distance of every product form a country's export basket as a whole. We call this measure density. It is the distance of good *i* from country *c*'s export basket at time *t*. It is the sum of all paths leading to the product in which the country is present, scaled by the total number of paths leading to that product. As with proximity, we define x based on whether or not the country has revealed comparative advantage in the product (if RCA>=1). Density varies from 0 to 1, with higher values indicating that the country has achieved comparative advantage in many nearby products, and therefore should be more likely to export that good in the future.

$$density_{i,c,t} = \left(\frac{\sum_k \varphi_{i,k,t} x_{c,k,t}}{\sum_k \varphi_{i,k,t}} \right)$$

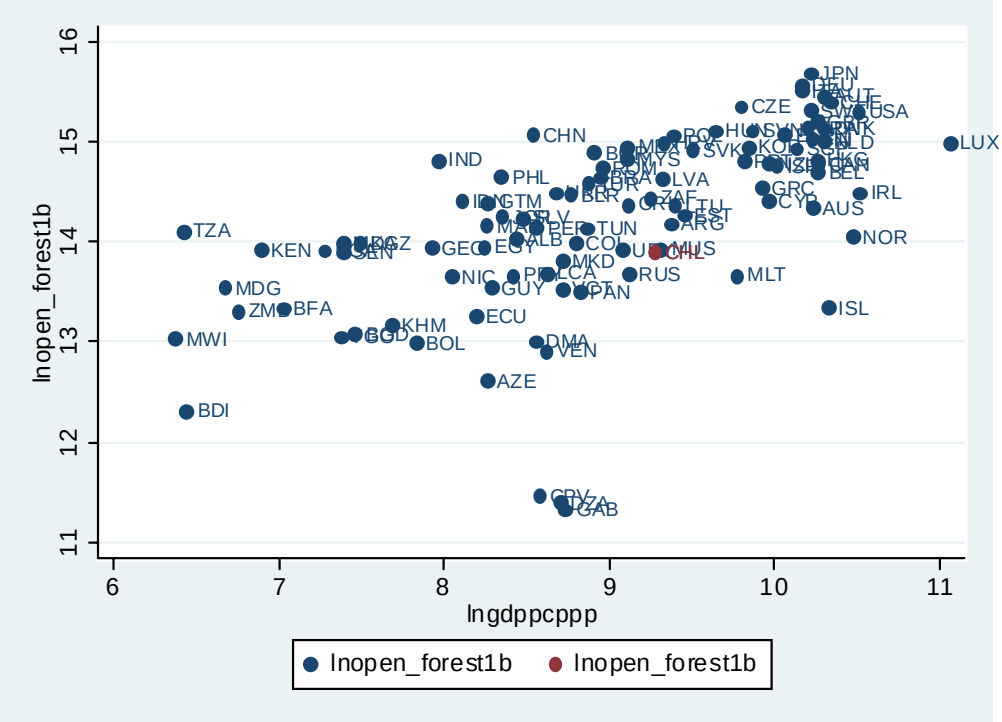
Density is a key variable in the process of growth diagnostics: it can be taken as an indicator of the degree of coordination needed to produce any given product. If the product is very near to the current export basket, density will be high, meaning that most of the capabilities needed in the new sector will already exist in other sectors. On the other hand, if density is low, then the human capital, physical capital, property rights, infrastructure, and every other sector-specific factor of production that the sector needs will not exist, and can not be easily adapted from what does exist.

To measure the 'option set' for Chile as a whole implied by its export basket, we need to use density, which is at the country/product level, to measure the opportunity set for the country as a whole. This measure, called 'open forest', answers the question "how green is your valley"—is the current export basket in a part of the product well-connected to other new and valuable opportunities for structural transformation, or is it in a sparse, unconnected part of the product space. It is calculated as follows:

$$open\_forest_{c,t} = \sum_i \sum_j \left[\frac{\varphi_{i,j,t}}{\sum_i \varphi_{i,j,t}} \left(1 - x_{c,j,t}\right) x_{c,i,t} PRODY_{j,t} \right]$$

Hausmann & Klinger (2006) show that open forest is highly significant in determining the future growth of export sophistication at the country level. Countries with a high level of open forest enjoy faster subsequent growth in export sophistication and overall economic growth. The following figure shows open forest vs. GDP for a cross-section of countries, with Chile indicted in red.

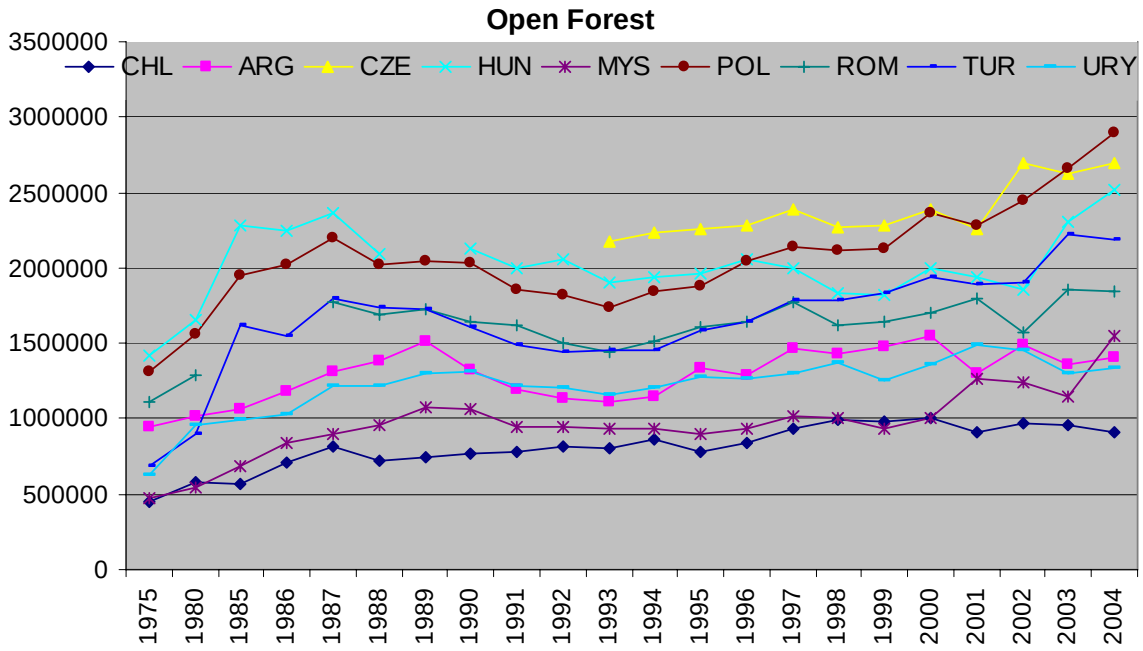
Figure 22
Open Forest vs. GDP per Capita (log), 2004



Source: Author's calculations using UN COMTRADE

As observed in the figures of the product space, Chile has a surprisingly low level of open forest, meaning its option set for future structural transformation is not attractive. Open forest over time is plotted below for Chile and comparator countries.

Figure 22
Open Forest over time, Comparative



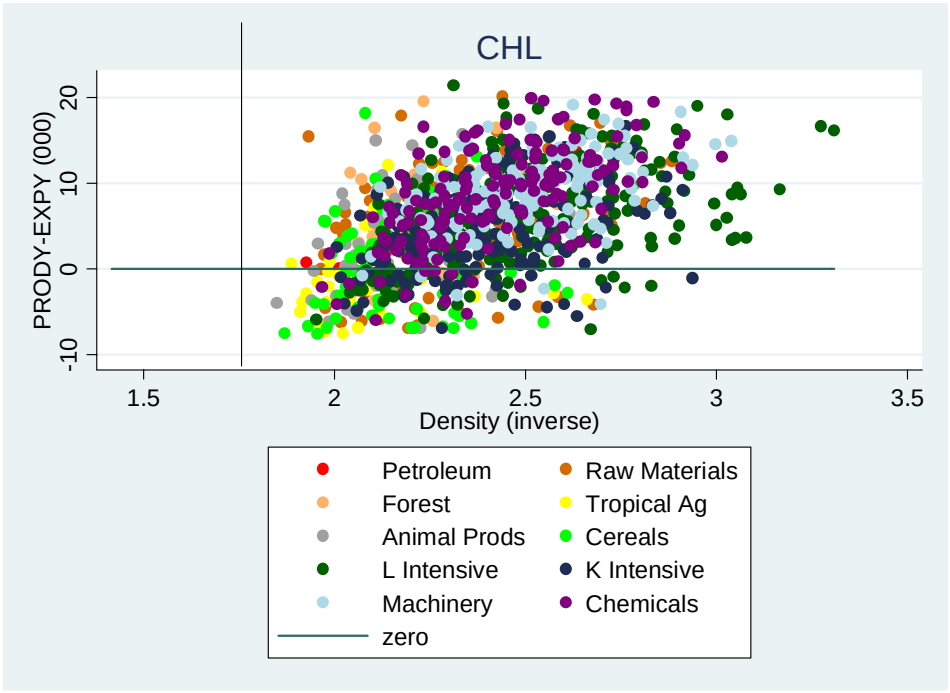
Source: Author's calculations using UN COMTRADE

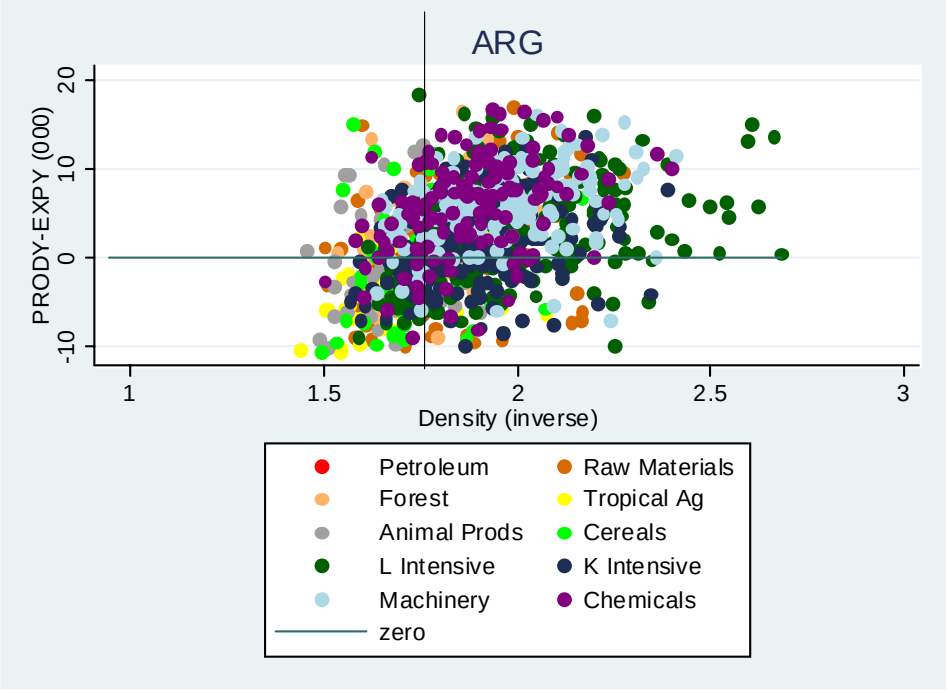
As with export sophistication, Chile has a low value of open forest, and has fallen behind over time. This figure provides a clear explanation for Chile's lack of structural transformation and upgrading of the export basket: the country has very few options for structural transformation. It has specialized in an export basket that entails specific capabilities with few alternative uses.

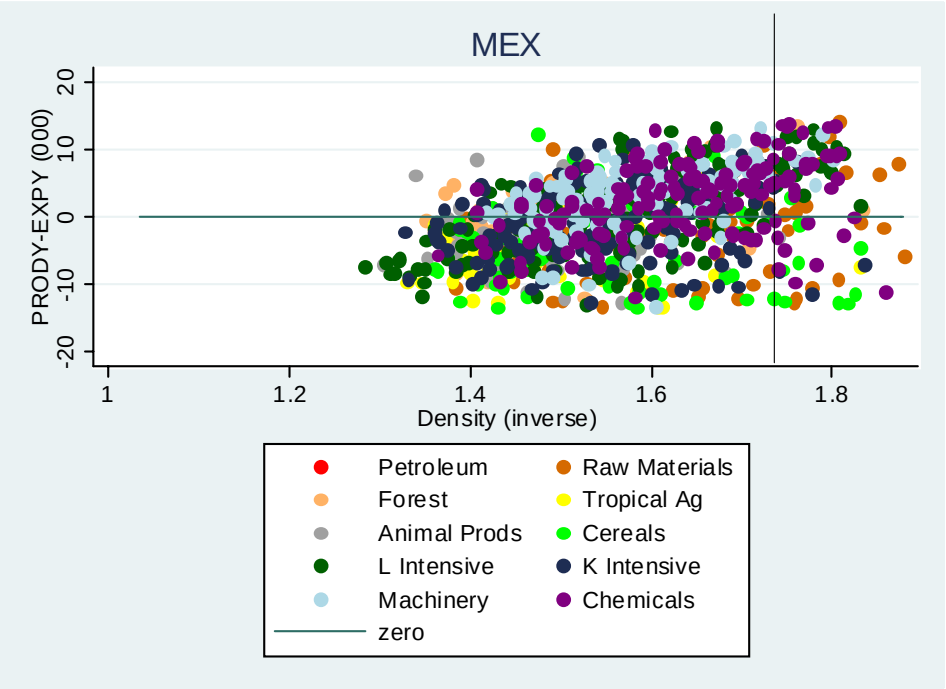
Interestingly, we see that Malaysia's open forest was equally low in 1975, and only recently has surpassed Chile's. This suggests that Malaysia's rapid structural transformation was surprising given its orientation in the product space.

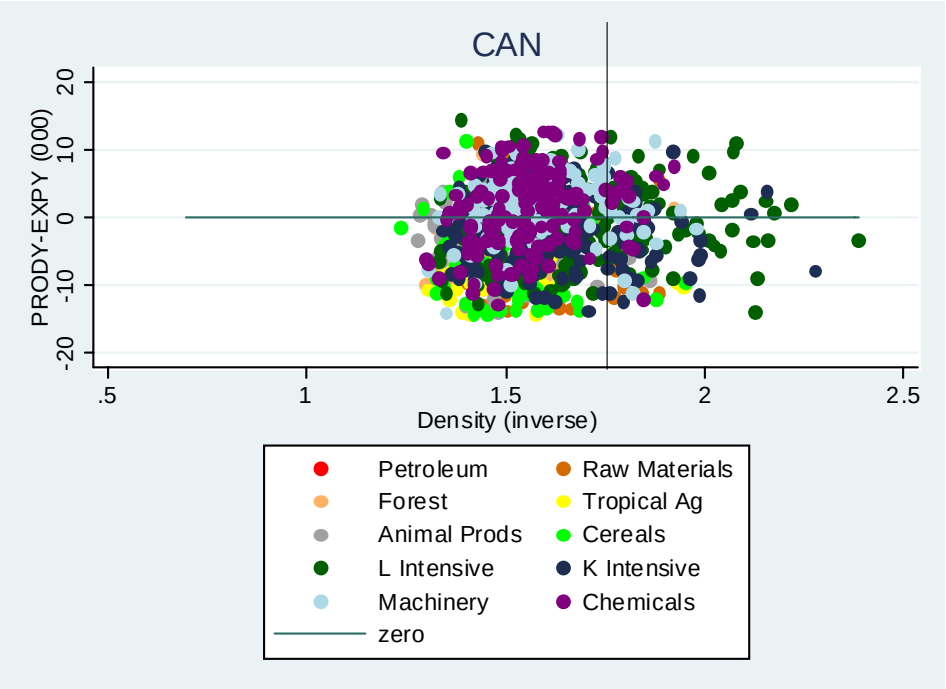
Using densities, we can show graphically how the product space looks from the point of view of Chile. Each product not currently exported with comparative advantage has a particular distance from the country's current export basket. In addition, each of these products has a level of sophistication, measured by PRODY. We can plot each of these products according to their distance (x-axis: the inverse of log(density), meaning that a smaller value represents a product that is *closer* to the current productive structure) and sophistication (y-axis), and also color-code them corresponding Leamer commodity clusters. This is shown below for Chile and some comparator countries. The horizontal line drawn where PRODY of the good equals the EXPY of the country. Products below that line are less sophisticated than the country's export basket as a whole. We also show a vertical line at an inverse log density of 1.75, for cross-country comparisons.

Figure 23
Density (log inverse) vs. PRODY-EXPY, 2004
Chile, Argentina, Mexico, and Canada









The x-axis is distance (-1*log(density), meaning that smaller values indicate the product is closer to the current basket), and the y-axis is prody (PPP) minus EXPY (PPP). The horizontal line indicates the level where the PRODY of the good equals EXPY of the country, i.e. the good is not more sophisticated than the current export basket. Source: Author's calculations using UN COMTRADE.

From the point of view of adding valuable new exports to the current basket, the ideal location on this plane is the upper-left quadrant: goods that are close and also highly sophisticated. These figures suggest a tradeoff between proximity and export sophistication. The products that are closest to the current export basket are easiest to

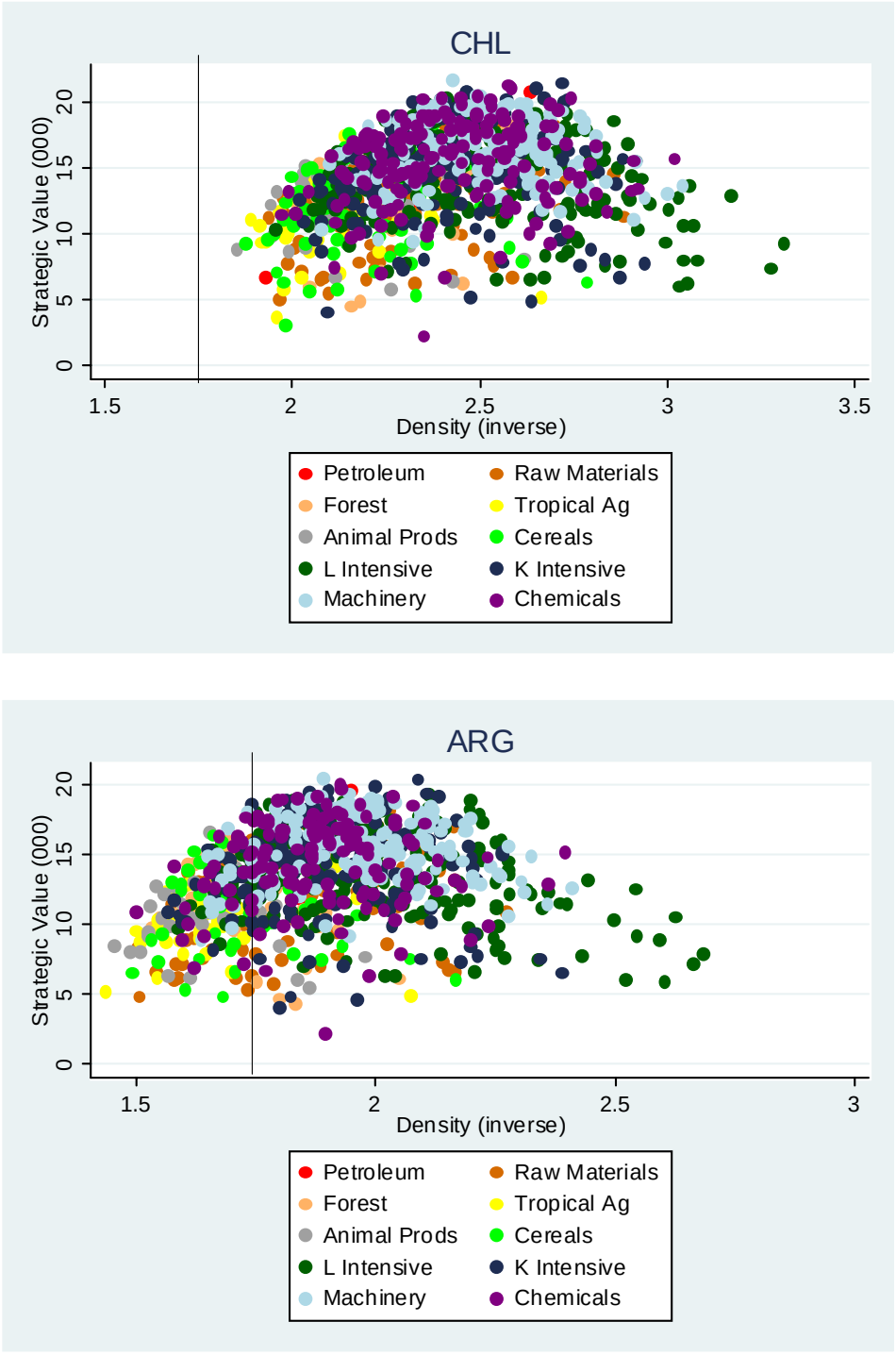
move towards, yet these nearest products are often not of a high level of sophistication. The more sophisticated products are further away from the current structure of production. However, there is an efficient frontier in this tradeoff. Some products are both further away *and* of lower sophistication than other potential exports. Chile's efficient frontier is dominated by raw materials, animal products, and other agriculture. Moreover, Chile is poorly positioned in this space: there is nothing within 1.75, upscale or not. Canada, Mexico, and even Argentina have a much richer option set.

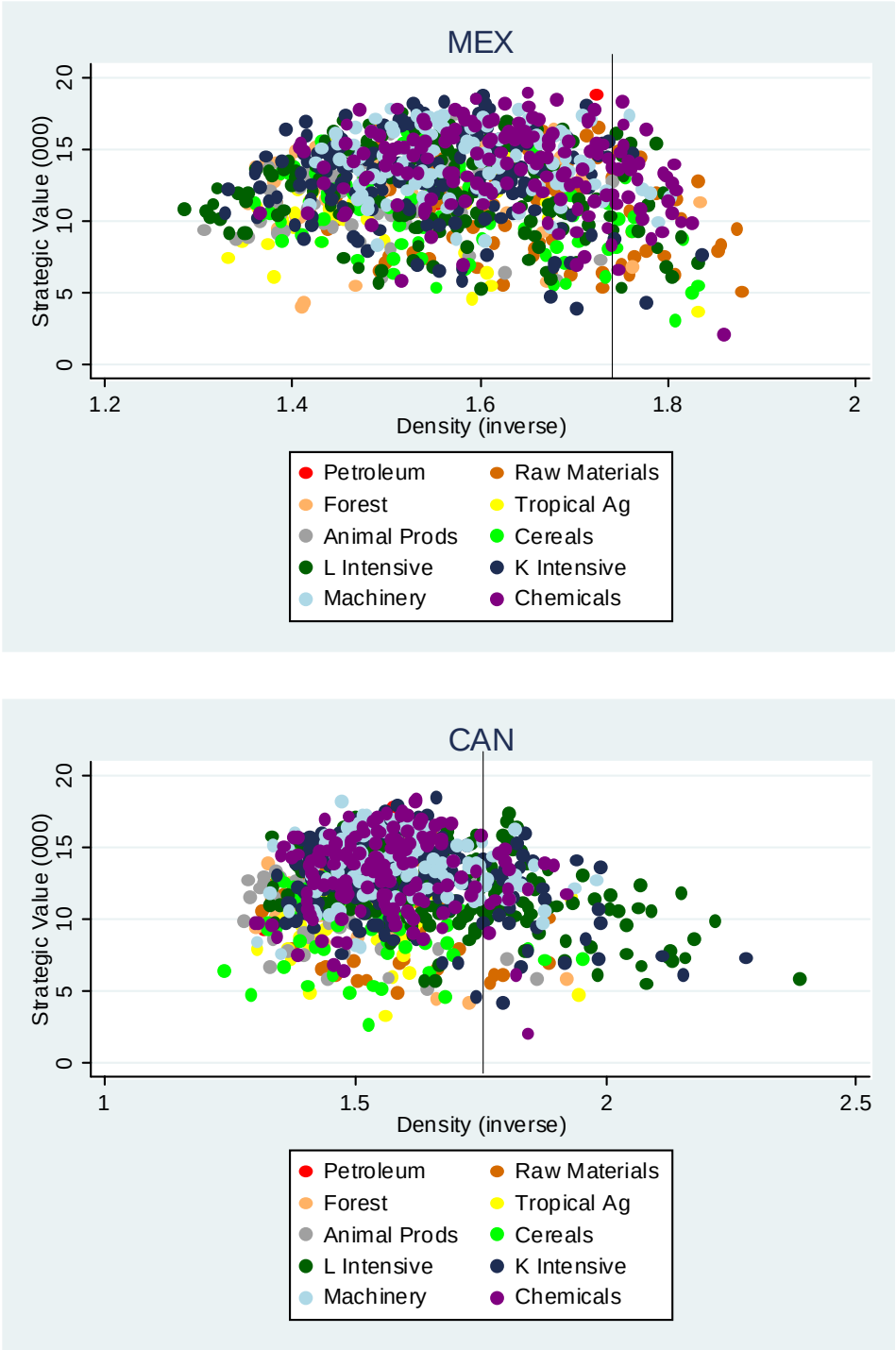
We can also create similar plots that illustrate a products *strategic value* rather than sophistication. As can be clearly seen above in the figures of the product space, not all goods were created equal in terms of their strategic value. Some products are in a dense part of the product space, meaning that they are intensive in capabilities that are easily deployed to a wide range of other goods. The implication is that successfully producing these goods would create capabilities with significant value for other new products. On the other hand, other products are located in the periphery, or in a part of the product space where Chile has already achieved comparative advantage and acquired the requisite productive capabilities. Therefore, these products have a low strategic value, as successfully producing them would offer little in terms of future structural transformation, even if they are highly valuable in their own right (i.e. have a high PRODY).

We can measure this strategic value of every good not currently exported with comparative advantage using open forest. This is done by calculating what would happen to open forest if that good were added to the export basket. If a product is closely connected to a wide range of other valuable products not currently exported by Chile, it would result in a large increase in open forest, and therefore have high strategic value as it would greatly expand the country's option set.

Below we plot the distance of all products not exported with comparative advantage by Chile in 2004 against their strategic value. Again, the ideal location is the upper-left quadrant: products that are nearby, meaning easier to move to, and that have high strategic value, meaning that they themselves lead to new and nearby opportunities for structural transformation. This is shown below for Chile, Argentina, Mexico, and Canada.

Figure 24
Density (log inverse) vs. Strategic Value, 2004
Chile, Argentina, Mexico, and Canada





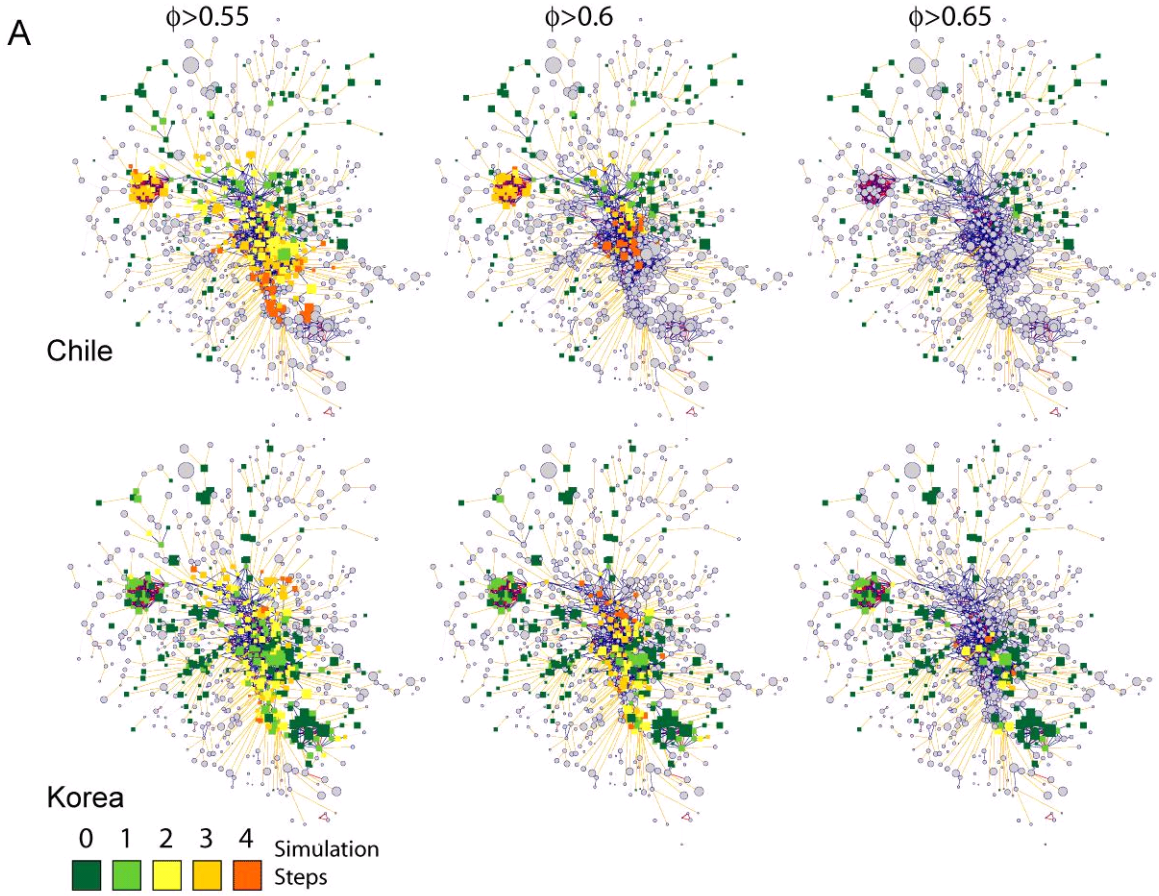
The x-axis is distance (-1*log(density), meaning that smaller values indicate the product is closer to the current basket), and the y-axis is the marginal increase in open forest if that product were added to the export basket. Source: Author's calculations using UN COMTRADE.

According to these figures, Chile is in a disconnected part of the product space. The structure of this space implies that a country's pattern of specialization could represent a 'stairway to heaven', with many nearby products that themselves have other nearby products, creating a path of self-sustaining structural transformation to a sophisticated

export package. On the other hand, an export basket could signal a dead end, where the accumulated capabilities in the economy have no alternative uses, and there are no nearby opportunities.

Does Chile's export basket signal a 'stairway to heaven'? We can address this question by simulating future diffusion given the current pattern of specialization. A graphical simulation using 2000 data, which can be found in Hidalgo et al. (forthcoming) suggests that Chile's export basket is more of a dead end than a stairway to heaven. In this figure, reproduced below, we can see the process of diffusion in the product space of Chile, compared to Korea. In each step, we allow jumps above different cutoffs of proximity, and then repeat this process for four steps. The products occupied in each step of the diffusion are shaded according to the legend.

Figure 25
Simulated Diffusion in the Product Space

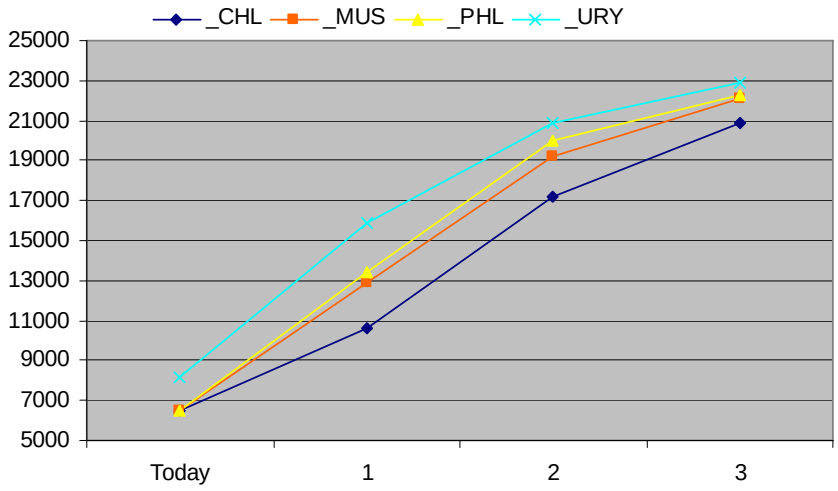


Source: Hidalgo et al. (forthcoming)

If we restrict diversification to only those products within a proximity of 0.65, Chile, unlike Korea, does not diffuse. It is only when we allow for larger jumps (all products with proximity of 0.6 or lower) that Chile is able to diffuse rather slowly within the product space. This is worrying because jumps of this distance are empirically infrequent (Hidalgo et al. forthcoming).

We can perform a similar simulation using 2005 data. We simulate jumps to all products with a density of 0.55 or greater, and then measure the evolving sophistication of the export package as the average PRODY of the top 50 products over multiple iterations. This is illustrated below for Chile and a group of comparator countries.

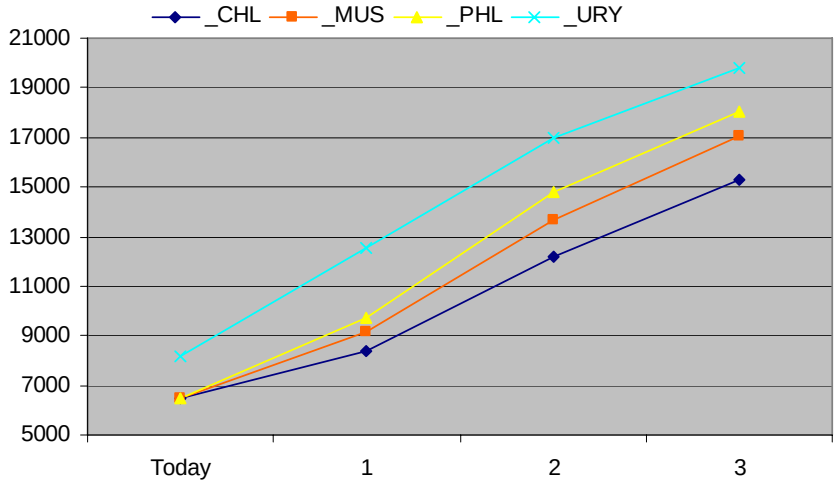
Figure 26
Simulated Diffusion, Jumps at 0.55 Proximity & More



Source: Author's calculations using UN COMTRADE

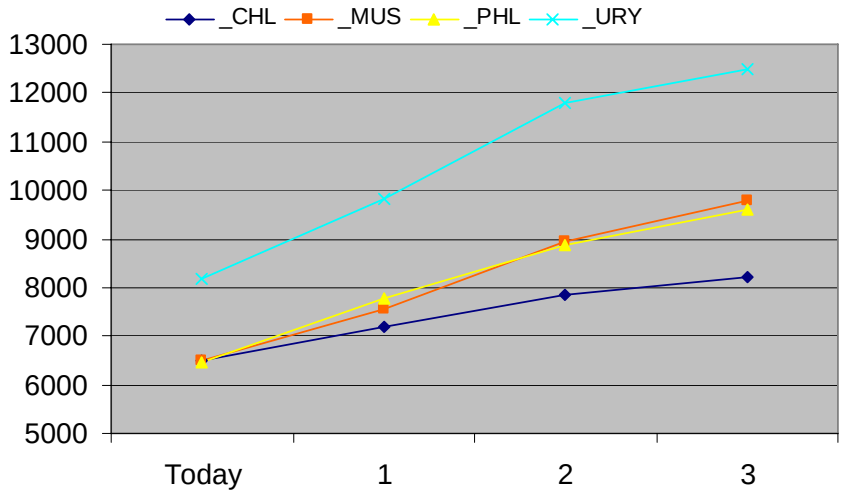
We see that Chile converges to a slightly lower level of export sophistication, and at a slower rate, than other countries with similarly low levels of current export sophistication. Moreover, jumps to products with a density of 0.55 are not very common. We therefore repeat the analysis below with higher density cutoffs, first 0.6, then 0.65.

Figure 27
Simulated Diffusion, Jumps at 0.60 Proximity & More



Source: Author's calculations using UN COMTRADE

Figure 28
Simulated Diffusion, Jumps at 0.65 Proximity & More



Source: Author's calculations using UN COMTRADE

Chile converges to progressively lower levels of export sophistication, and at slower rates. Even controlling for the low level of export sophistication today, Chile's future path of structural transformation looks bleak.

For illustrative purposes, below we show what products lie on this path of diffusion (allowing for jumps with densities of 0.55 or more). We take the new goods added to the set at each iteration, aggregate to the sector level, calculate average PRODY for the sector, and list the top 10 sectors by PRODY. Note that a sector may appear more than once because different products belonging to it may be added at different iterations.

Table 2
Simulated Diffusion Path
First Iteration

Sector	Average PRODY
Manufacture of made-up textile goods except wea ing apparel	33496
Grain mill products	21010
Manufacture of agricultural machinery and equipment	20226
Manufacture of non-metallic mineral products not elsewhere classified	19623
Manufacture of metal and wood working machinery	19568
Manufacture of dairy products	18574
Manufacture of cocoa, chocolate and sugar confectionery	17078
Manufacture of structural metal products	16681
Sawmille, planing and other wood mills	16589
Machinery and equipment except electrical not elsewhere classified	16120

Second Iteration

Sector	Average PRODY
Machinery and equipment except electrical not elsewhere classified	28765
Manufacture of rubber products not elsewhere classified	22864
Slaughtering, preparing and preserving meat	22720
Non-ferrous metal basic industries	20651
Tyre and tube industries	20419
Manufacture of synthetic resins, plastic materials and man-made fibres except glass	20355
Manufacture of motor vehicles	20215
Manufacture of non-metallic mineral products not elsewhere classified	19361
Manufacture of professional, scientific, measuring & controlling equip.	18201
Manufacture of plastic products not elsewhere classified	18051

Third Iteration

Sector	Average PRODY
Manufacture of rubber products not elsewhere classified	31983
Iron and steel basic industries	27170
Manufacture of basic industrial chemicals except fertilizer	23855
Manufacture of textiles not elsewhere classified	23562
Manufacture of metal and wood working machinery	22434
Manufacture of special industrial machinery except metal and wood working machinery	21241
Manufacture of containers and boxes of paper and paperboard	21060
Machinery and equipment except electrical not elsewhere classified	20464
Printing, publishing and allied industries	20257
Manufacture of synthetic resins, plastic materials and man-made fibres except glass	19741

Fourth Iteration

Sector	Average PRODY
Machinery and equipment except electrical not elsewhere classified	28690
Manufacture of drugs and medicines	25361
Iron and steel basic industries	24515
Manufacture of professional, scientific, measuring & controlling equip.	23962
Manufacture of non-metallic mineral products not elsewhere classified	23613
Manufacture of metal and wood working machinery	22206
Manufacture of glass and glass products	21598
Manufacture of basic industrial chemicals except fertilizer	21544
Manufacture of made-up textile goods except wea ing apparel	20975
Shipbuilding and repairing	19869

Fifth Iteration

Sector	Average PRODY
Manufacture of photographic and optical goods	28905
Manufacture of drugs and medicines	26840
Manufacture of radio, television and communication equipment and apparatus	23932
Manufacture of special industrial machinery except metal and wood working machinery	23131
Manufacture of basic industrial chemicals except fertilizer	22558
Manufacture of agricultural machinery and equipment	22313
Manufacture of motorcycles and bicycles	21789
Manufacture of fabricated metal products except machinery and equipement	21514
Non-ferrous metal basic industries	21480
Manufacture of professional, scientific, measuring & controlling equip.	20953

Source: Author's Calculations using UN COMTRADE

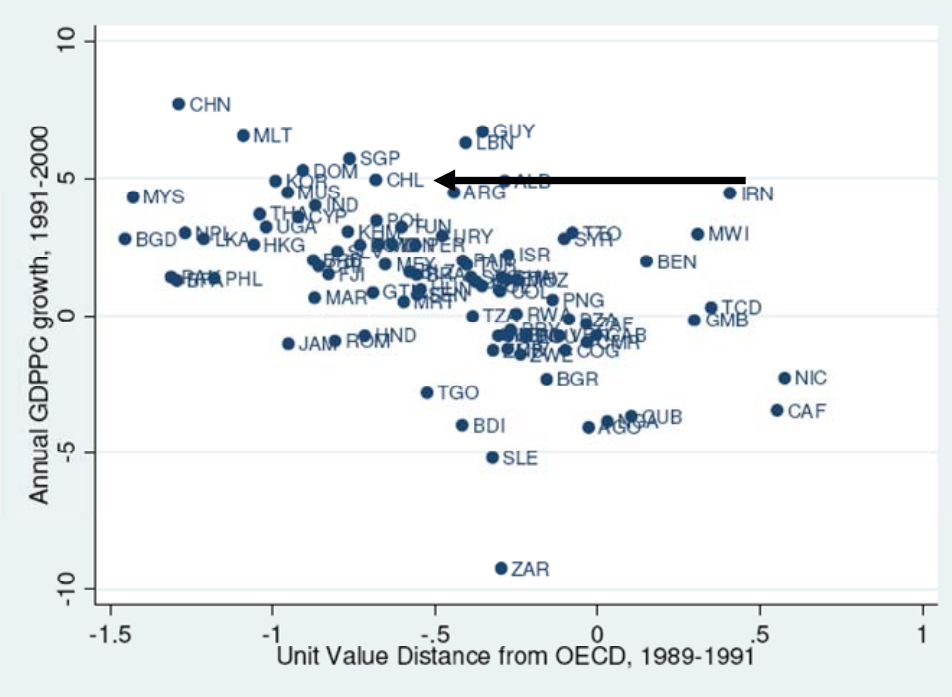
Roughly, the simulated path of diffusion is dairy-based products, wood processing and metal processing to cars and plastics to industrial chemicals and machinery to pharmaceuticals and electronics. This exercise in no way means that this is a desirable path. Moreover, it allows jumps over distances that are so long that they are empirically infrequent, while at the same time Chile's monkeys have jumped only very short distances over the past three decades. The key result is that Chile's export sophistication

converges slower than other countries with similarly valued baskets, and actually diverges if you only allow for shorter jumps. The country's export package implies few opportunities for structural transformation.

Given low EXPY and open forest, recent economic growth in Chile has been surprisingly strong. This has not been accomplished by moving to new merchandise export products. But another dimension of export growth is upgrading quality within existing products. Recent research finds that when a country exports a new product, they tend to enter the market at a lower quality. But this quality, as measured by unit prices, converges to the global frontier at a rate of 5 to 6% per annum *unconditionally* (Hwang 2007). That is, once a country begins to successfully export a particular product, its quality increases to the global frontier unconditionally at a relatively rapid pace.

The implication of this finding is quite important: countries that are currently farther away from the global frontier in products already exported have access to a relatively rapid, and seemingly unconditional, channel of growth. The figure below shows this result, with output growth on the y-axis and the room for quality upgrading within existing products on the x-axis. Unit value distances are calculated for each product, and then combined with weights according to that product's share of the country's total exports. A larger negative value indicates a larger gap between the prices that country garners for its exports per unit, and the frontier price. And as shown in this graph, countries with room for upgrading in existing products grow faster.

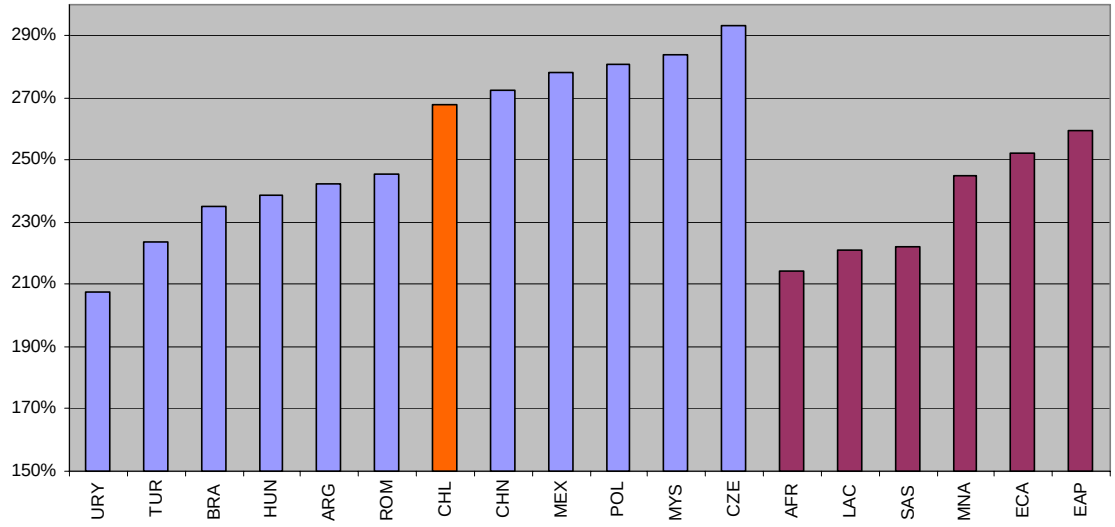
Figure 29
Unit Value Gaps and Growth



Unit value distance is the log difference between unit values in the highest-priced country's exports and the unit values in the country's exports, for each product exported. These gaps are then weighted by the share of each good in total exports. Source: Hwang 2007

Below we show the gaps for Chile and a group of comparators using the most recent data available. Here the gaps are shown in percentages, and are inverted, so a larger value indicates a larger unit value gap: more room for quality upgrading. Chile had one of the highest unit value gaps in Latin America at the end of the 1990s, meaning that there remains room to increase exports through quality upgrading.

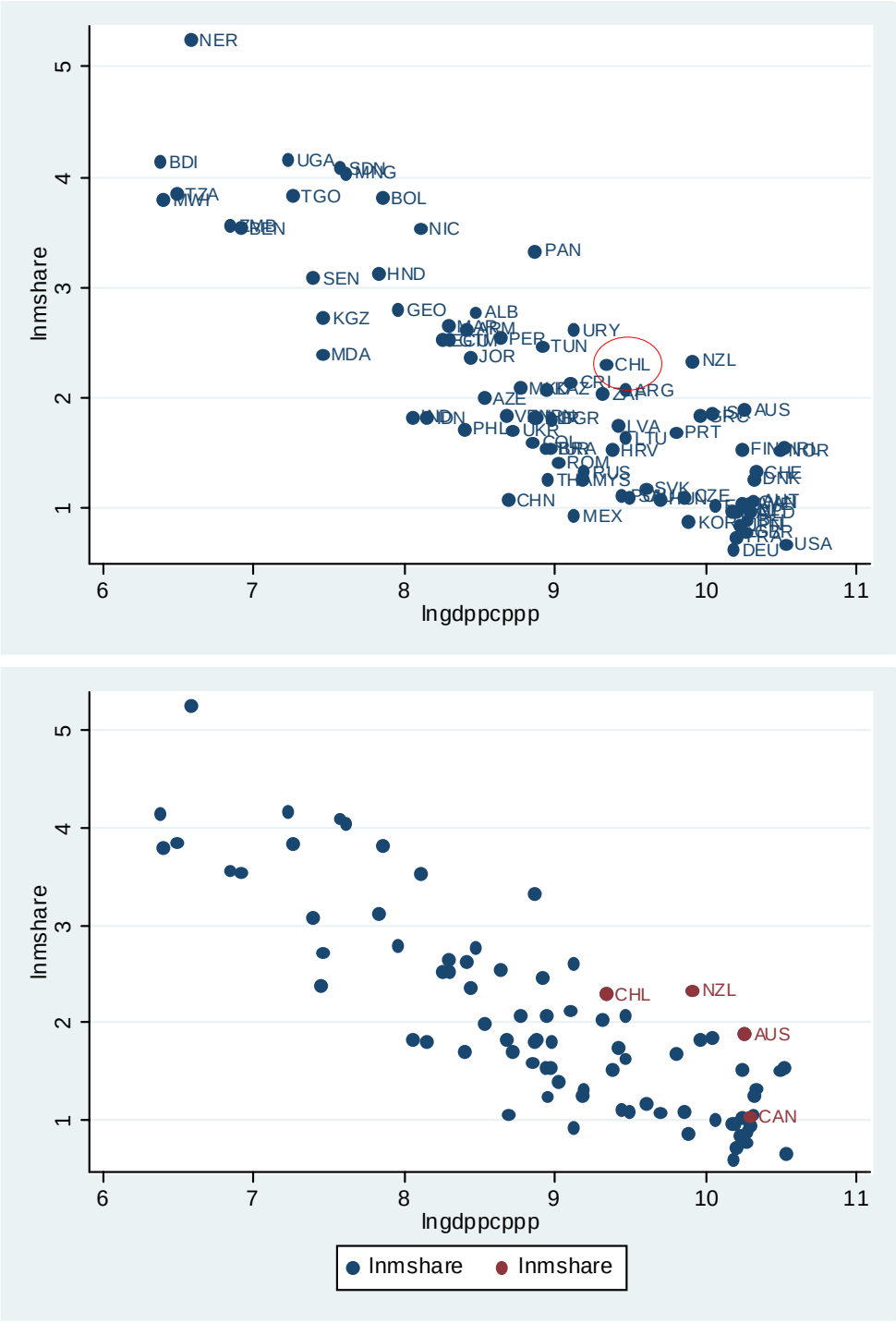
Figure 30
Unit Value Distance, 1998-2000 (avg)



Source: Hwang (2007)

Finally, in addition to 'better of the same', exports can grow simply through 'more of the same'. How much room does Chile have to grow through increasing its market share in existing sectors? To consider this, we consider all products exported with comparative advantage in 2004 and calculate the average value of the RCA index. A higher value indicates that among those products already exported, the country has very high market share, and therefore less room to grow through 'more of the same'. This is shown in the following figure, first for the complete cross-section of countries, followed by a scatterplot with Chile, Australia, Canada, and New Zealand highlighted.

Figure 31
Average RCA in Export Basket vs. GDP per capita (PPP, logs), 2004



Source: Author's calculations using UN COMTRADE and WDI

These figures show that richer countries have substantial presence in many products, whereas poorer countries have a high market share in a narrow range of products. The first figure shows that Chile has a comparatively high average RCA index given its level

of income. That is, the country has larger market shares in its export goods than most countries at that level of income. This suggests that there is less room to grow through more of the same. However, as seen in the second figure, both New Zealand and Australia are also outliers in terms of large market shares in existing export products, suggesting that this may in part be a characteristic of advanced natural resource exporters.

Conclusion

We have seen that Chile has enjoyed significant growth in service exports, and has some remaining room to grow through upgrading quality in existing export products. However, there is little room to grow through increasing market share in existing exports. More worryingly, Chile has an extremely low level of export sophistication, and has specialized in a very disconnected part of the product space with few opportunities for future structural transformation.

Therefore, although life is good now, there is trouble on the horizon. Growth has been achieved through small upgrading and expanding in those parts of the space that were occupied twenty years ago, while the fundamental value of Chile's export package is stagnant and falling behind comparator countries. New export activities are not emerging. We have seen that this is in part due to the structure of the product space and Chile's orientation therein. The current set of productive capabilities has few alternative uses, or in other words, there are no new products nearby. Capabilities that generate self-sustaining transformation do not currently exist, and will not appear automatically. Incremental jumps from the current export basket will simply lead to more falling behind.

Given that room for quality upgrading will be exhausted at some point, and there are no logical candidates for piecemeal horizontal diversification in the private sector, more speculative activities belong in the government's portfolio. New areas of the product space must be explored, and international experience suggests that this is a public policy issue, from public coordination in Cancun's tourism sector to government procurement in the defense industries leading to the aerospace industry in the USA and electronics industry in Israel, to specialized export processing zones for electronics in Malaysia and active promotion of targeted FDI in Ireland. Chile needs a policy framework that creates incentives for firms that may yet not exist, or foreign firms that do exist but are not present in Chile, to explore father reaches of the product space. This requires an approach that is different from one based on the dialogue with existing activities and improving existing processes. It will require the identification and removal of sector specific obstacles in areas that do not yet exist. Hausmann, Rodrik and Sabel (2007) propose ideas to address the obstacles to productive transformation that seem so prevalent in Chile.

References

Balassa, B. 1986 “Comparative advantage in manufactured goods: a reappraisal.” The Review of Economics and Statistics 68(2): 315-19.

Hausmann, R., J. Hwang, and D. Rodrik. 2006. “What You Export Matters.” Working Paper #11905. Cambridge, MA: National Bureau of Economic Research.

Hausmann, R., and B. Klinger. 2006. “Structural Transformation and Patterns of Comparative Advantage in the Product Space.” Harvard University Center for International Development Working Paper #128.

Hausmann, R., and B. Klinger. 2007. “The Structure of the Product Space and the Evolution of Comparative Advantage.” Harvard University Center for International Development Working Paper #146 (extended and revised version of #128).

Hausmann, R., and D. Rodrik. 2003. “Economic Development as Self-discovery.” Journal of Development Economics, 72:603–633.

Hausmann, R., and D. Rodrik. 2006. “Doomed to Choose: Industrial Policy as a Predicament.” Center for International Development Blue Sky Conference Paper, September.

Hausmann, R., D. Rodrik, and C. Sabel 2007 “Reconfiguring Industrial Policy”, Center for International Development, Harvard University.

Hwang, J. 2007. “Introduction of New Goods, Convergence and Growth.” Department of Economics, Harvard University, mimeo.

Lall, S. 2000. “The technological structure and performance of developing country manufactured exports, 1985-1998” Queen Elizabeth House Working Paper #44, University of Oxford.

Leamer, Edward E. 1984. *Sources of Comparative Advantage: Theory and Evidence*. Cambridge MA: The MIT Press.