Economic Complexity Report for Western Australia

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ECONOMIC COMPLEXITY REPORT FOR WESTERN AUSTRALIA

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Growth Lab
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Glossary

The following glossary is meant to provide an intuitive explanation for some of the jargon found in this document. Additional mathematical detail can be found online at the Growth Lab website: www.atlas.cid.harvard.edu/glossary

Economic Complexity

A measure of the knowledge in a society as expressed in the products it makes. The economic complexity of a place is calculated based on the diversity of products a place produces and their ubiquity, or the number of the places able to produce them (and those places' complexity). Places that are able to sustain a diverse range of productive knowhow, including sophisticated, unique knowhow, are able to produce a wide diversity of goods, including complex products that few other places can make.

Economic Complexity Index (ECI)

An index of places based on how diversified and complex their production basket is. Places that are home to a great diversity of productive knowhow, particularly complex specialized knowhow, are able to produce a great diversity of produce, including highly unique products. The complexity of a place's production is found to be highly predictive of current income levels, or where complexity exceeds expectations for a place's income level, the place is predicted to experience more rapid growth in the future. ECI therefore provides a useful measure of economic development.

Complexity Outlook Index (COI)

A measure of how many complex products are near a place's current set of productive capabilities. The COI captures the ease of diversification for a place, where a high COI reflects an abundance of nearby complex products that rely on similar capabilities or know-how as that present in current production. Complexity outlook capture the connectedness of an economy's existing capabilities to drive easy (or hard) diversification into related complex production. A low complexity outlook indicates that a place has few products that are a short distance away, so it will it difficult to acquire new know-how and increase its economic complexity.

Knowhow

Knowhow is the tacit ability to produce a product. Also known as productive capability, knowhow refers to productive knowledge that goes into making products. Places grow faster by diversifying the productive knowledge they have to make a wider variety of products of increasing complexity. Knowhow, as tacit knowledge that only exists in brains, stands in contrast to embedded knowledge where all knowledge is held in technology (e.g. in an iPhone); and codified knowledge, where all knowledge is explained and detailed in codes or blueprints. Knowhow is better conceived as the ability to walk, as tacit knowledge that cannot be fully explains using words and is the slowest to transfer by requiring time-intensive processes of imitation and repetition. While embedded knowledge (e.g. iPhones) can be shipped across the world and codified knowledge (e.g. Wikipedia) can be accessed through media, we believe it is the slow transfer of knowhow that explains the slow, incomplete diffusion of technology and production around the world and stands at the heart of the economic growth process. Policies that aim to speed up the diffusion of or diversify the knowhow of a society hold important implications on the pace of economic growth – and its fairness.

Complexity Outlook Gain (COG)

Measures how much a location could benefit in opening future diversification opportunities by developing a particular product. Complexity outlook gain quantifies how a new product can open links to more, and more complex, products. Complexity outlook gain classifies the strategic value of a product based on the new paths to diversification in more complex sectors that it opens up. Complexity outlook gain accounts for the complexity of the products not being produced in a location and the distance or how close to existing capabilities that new product is.

Product Complexity Index (PCI)

Ranks the diversity and specialization of the productive knowhow required to produce a product. PCI is calculated based on how many other places can produce the product and the economic complexity of those places. In effect, PCI captures the amount and sophistication of knowhow required to produce a product. The most complex products (that only a few, highly complex places can produce) include sophisticated machinery, electronics, and chemicals. The least complex products (that nearly all places including the least complex can product) include raw materials and simple agricultural goods. As an example, specialized machinery is said to be complex as it requires a range of knowhow in manufacturing, including the coordination of a range of highly skilled individuals' knowhow.

Revealed Comparative Advantage (RCA)

A measure of whether a place produces a certain good, based on the relative advantage or disadvantage a place has in the export of a certain good. We use Balassa's definition, which says that a place is an effective producer of a good if it produces more than its "fair share," or a share that is at least equal to the share of total world production that the product represents (RCA greater than one). One example: in 2010, soybeans represented 0.35% of world trade with exports of $42 billion. Of this total, Brazil exported nearly $11 billion of soybeans. Since Brazil's total exports for that year were $140 billion, soybeans accounted for 7.8% of Brazil's exports. By dividing 7.8% / 0.35%, we find Brazil has an RCA of 22 in soybeans, meaning that Brazil exports 22 times its "fair share" of soybean exports so we can say that Brazil has a high revealed comparative advantage in soybeans.

Diversity

A measure of how many different types of product a place is able to make. The production of a good requires a specific set of knowhow; therefore, a place's total diversity is another way of expressing the amount of collective knowhow held within that place.

Ubiquity

Ubiquity measures the number of places that are able to make a product.

1. Introduction

The Government of Western Australia (WA), acting through its Department of Primary Industries and Regional Development (DPIRD), invited the Growth Lab of the Center for International Development (CID) at Harvard University to partner with the state to better understand and address constraints to economic diversification through a collaborative applied research project. The project seeks to apply growth diagnostic and economic complexity methodologies to inform policy design in order to accelerate productive transformation, economic diversification, and more inclusive and resilient job creation across Western Australia. This Economic Complexity Report represents the first of three initial planned deliverables (Economic Complexity Report, Growth Perspective, and Policy Recommendations Brief). This report reflects important and iterative feedback on draft version, collected through DPIRD, and incorporates observations from a one-week visit to WA by the Growth Lab team in March 2020 during which time the team visited businesses and Regional Development Commissions in six regions.

This report is organized in six sections, including this brief introduction. Section 2 explains the methodology of economic complexity, including its theoretical foundations and main concepts, as well as the adjustments that were required to obtain the required export data at a subnational level and incorporate the service sector to the analysis. Section 3 describes the structure of the WA economy, identifying its productive capacities and exploring its complexity profile. This is done at the state, regional, and city levels. Section 4 identifies industries with high potential and organizes them into groupings to capture important patterns among the opportunities. Section 5 contextualizes the opportunities further by identifying relevant viability and attractiveness factors that complement the complexity metrics and consider local conditions, as well as a criterion for regional participation in the state-wide diversification strategy. Finally, Section 6 summarizes the main findings of this report and discusses implications for Government of WA strategy and policy toward capitalizing on these revealed opportunities.

It is worthwhile to note that even though the COVID-19 pandemic has had a rapid and profound economic impact in WA over the past few months, the fundamental findings of this report remain unchanged. In fact, the economic shocks that have emerged from the public health crisis underscore the importance of diversifying WA's job base while continuing to maximize the benefits of its world-class mining sector. Interestingly, the global shifts in production and consumption that will emerge in the shadow of this crisis may create new opportunities for many of the strategic industries identified in this report (particularly in backward linkages to WA's main industries, advanced manufacturing, and professional services, as well as in the healthcare sector). Strategic considerations of global demand as the world recovers COVID-19 may therefore be an important avenue for future work toward acting upon the findings of this report. Meanwhile, the crisis of today may open new opportunities for policy innovations to solve problems that have slowed diversification in WA in the past.

2. Conceptual Framework

a) Theory of Economic Complexity

The theory of economic complexity, introduced by Hausmann, Hidalgo et al. (2011), is based on the realization that the development of products and services not only requires raw materials, labor and machinery, but also tacit knowledge (or "knowhow") of how to put inputs together to produce things and run business operations. This tacit knowledge tends to be the limiting factor for diversifying economic activities, because it is the most difficult component of production to transfer. Whereas many other inputs to production – including materials, tools, and blueprints – are relatively easy to trade and transfer, tacit knowledge of how to combine inputs efficiently and effectively can only be acquired through experience. Moreover, modern production requires far more knowhow than any single individual can acquire. Therefore, tacit knowledge is necessarily spread across many individuals who coordinate across teams and organizations.

To illustrate this dynamic, one might consider a hypothetical example of the barriers a company might face when trying to manufacture a sophisticated technological good – say, a cellphone – in a particular place. The company in question may very well be able to obtain blueprints and scientific documents that explain how to create a cellphone and its principles of operation. The company may be able to import the required raw materials and intermediate inputs used to construct a cellphone into the place where it operates, as well as the tools needed to put them together at a reasonable cost. It can even obtain an actual cellphone to examine its functionality. If all of this is eminently possible, why do so few places have companies that actually manufacture sophisticated goods such as cellphones? The answer is that few places have practical experience related to manufacturing cellphones competitively. This makes it very difficult to start producing cell phones in a place where they have not been produced before, especially by a company that has never produced cell phones before. Meanwhile, existing cell phone manufacturing companies tend to locate in places that have practical experience all along the production process, or across multiple places that each have different tacit knowledge, prolonging the first mover advantage. However, once a place does produce a sophisticated product like a cell phone, it establishes a set of capabilities that can be repurposed for other similar products as well as for new products that are similar but have not been invented yet.

Some products and services incorporate large amounts of knowhow and types of knowhow that are valuable for multiple uses. In contrast, other products and services incorporate much less knowhow and/or knowhow that is not transferable for other valuable uses. As an analogy, different products and services can be understood as "words" whose production requires "letters" (knowhow-based capabilities), like in a game of *Scrabble*. The production of long and sophisticated words requires many letters, including some high-value letters, while few are needed to generate short and simple words. The knowhow embedded in places varies in terms of type and quantity. That is, some places have many diverse letters, which they can use in many combinations to make many different and valuable words, while others have few letters and letters with limited uses, which limits the possibility of creating new words. The differences in productive capacities brought by uneven "endowments" of letters are further amplified by the fact that the number of words that can be constructed increases exponentially as new letters are added.[1]

Ultimately, places develop the products and services (words) that their knowhow-based capabilities (letters) can support. Tools of economic complexity aim to measure and utilize the patterns that result. By observing patterns of production across places and time, we can infer and mathematically construct quantitative measures that capture the diversity of knowhow embedded in a place (Economic Complexity Index, ECI) and how much knowhow specific goods and services require (Productivity Complexity Index, PCI). Places with a high ECI are able to support a diverse set of economic activities, including activities that are not common across places, while places with low ECI support a less diverse set of activities, and those activities tend to be ubiquitous across places. Note that "complexity" is not the same as "sophistication," and we strive to not confuse the two words. Products and services can be sophisticated in that they are complicated to produce but can still be non-complex if the capabilities required to produce them are not able to be redeployed for many other products and services. Likewise, places can be sophisticated in that they produce complicated and high-value products but can still have low complexity if the capabilities required to produce their products cannot support diverse economic activities.

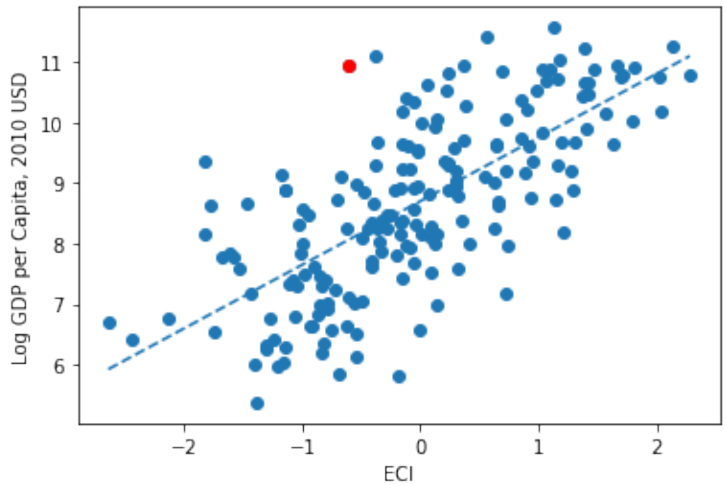
Given that economic complexity reflects the amount of knowhow that is embedded in the productive structure of an economy, it is not surprising to find a strong correlation between measures of complexity and income. **Figure 1** shows the relationship between per capita income and economic complexity across all countries of the world. At the same time, given that complexity and sophistication are not one in the same, it is also a fact of the world that some countries (Australia included), appear far away from the regression line.

Hausmann, Hidalgo et al. (2014) also found that the prediction errors in **Figure 1** – i.e. the difference between a country's actual income levels and those predicted by its complexity – tend to be predictive of future growth dynamics. Countries with an economic complexity greater than expected given their level of income tend to grow faster than countries that display a level of income that is higher than expected for their current level of economic complexity. In other words, countries positioned below the regression line are often poised to enter long periods of sustained growth, because if key constraints (such as infrastructure, access to financial capital, or institutional gaps) can be overcome then they can translate their existing stock of knowhow into higher output. Meanwhile, places above the regression line tend to be in a more precarious position (in terms of long-term growth) as they may be benefitting from a temporary positive shock, and if this boom is not leveraged to increase the sophistication of the economy to a level consistent with

[1] Thus, for example, in the English language, with 1 letter, "a", one word can be formed of up to 1 letter; with 3 letters, "a", "c" and "t", you can form up to 4 words of up to 3 letters ("a", "at", "cat" and "act"); with 4 letters, "a", "c", "t" and "r", you can form 9 words of up to 4 letters ("a", "at", "cat", "act", "rat", "car", "art", "tar" and "cart"); and with 10 letters, "a", "c", "t", "r", "o," l "," g "," s "," n "and" i ", you can form 595 words of up to 10 letters.

the current level of income, they run the risk of having their level of income fall toward the regression line when the boom ends.

Figure 1: Income per Capita and Economic Complexity by Country (2017), Australia in Red



Source: Own calculations based on World Bank WDI and the Atlas of Economic Complexity

The implication for developing countries (that are not as industrialized as Australia or WA) is that long-term growth and corresponding improvements in wellbeing tend to require a process of structural transformation where the private sector gradually gains productive capabilities. This allows the revealed comparative advantages of the economy to evolve and diversify over time. Countries that have transitioned from low-income to high-income economic systems have tended to diversify from primarily agricultural production into particular types of labor-intensive manufacturing (like garments) and onward to more sophisticated manufacturing and tradable services. As they grow, they do not give up most of the economic activities of the past but rather become more productive in those activities as they add new industries. This diversification process leads to rising wages across both old and new industries and makes countries more resilient to a variety of shocks – whether natural, macroeconomic, financial and technological – as economic activity and jobs are less concentrated and therefore less vulnerable to a single shock.

The implications for industrialized economies – including WA – that find themselves above the regression line are quite different. Many of these countries benefit from substantial resource wealth and some benefit also from very strong institutions that diminish the negative impacts of resource wealth, including a tendency toward inequality and boom-and-bust cycles. However, these countries stand to benefit from recognizing the risk inherent with resource-driven wealth: if the resources lose their value, national wealth will contract. Additionally, some of these countries struggle with the subnational implications associated with these types of economies. For instance, stabilization mechanisms that work well at a national level, may not work as well at a subnational level. They also often struggle sharing the benefits of that wealth, as in many instances rents from natural resources don't always translate into long-term material benefit for places they were extracted from. Finally, countries blessed with natural resource wealth face challenges for diversification of job opportunities that derive from the distorting macroeconomic influences that natural resources can have. Most commonly, this wealth can appreciate national currencies, which can crowd out the emergence of other economic opportunities that would provide more and better jobs. Such countries may want to actively pursue diversification for the benefits of resilience and inclusiveness, but the nature of their diversification paths will be necessarily different than developing countries.

A final critical theoretical foundation of economic complexity was introduced by Hausmann and Klinger (2006). They showed that the probability that a place develops the ability to produce a new product varies based on the set of products that it already produces. This allowed for the measurement of the similarity between products based on their shared capabilities. Based on this pattern, they proposed a measure of similarity or proximity between products. In essence, they measure the "proximity" between any pair of products based on the probability that countries are intensively engaged in both. The collection of all the resulting proximities can be visualized as a network connecting pairs of products based on their tendency to be co-exported by countries. They refer to this network as the Product Space and use it to study the productive structure of countries.

The structure of the Product Space, and a country's position within it, is crucial because it affects the ability of countries to move into new products. A highly connected position in the Product Space reflects relatively easier paths to diversification than a sparse position. Hausmann and Klinger (2006) find that the Product Space is highly heterogeneous: some sections are composed of densely connected groups of products whereas others are more loosely connected. This heterogeneity has significant implications for the speed and patterns of structural transformation: the ability of countries to diversify and to move into products that are more complex is crucially dependent on their initial location in the Product Space. The complete Product Space and Australia's position in the space are shown **Figure 2.**

The location of a country's production in the Product Space captures information regarding both the productive knowledge that it possesses and the capacity to expand that knowledge by moving into other nearby products. The strategic positioning of a place in the Product Space can be leveraged as an insightful tool for formulating economic diversification strategies.[2] This tool is equally applicable for both developing countries seeking to accelerate structural transformation and industrialized countries that want to diversify beyond their natural resources. What differs is the initial position in the Product Space for the countries and the type strategies that result. Australia's position in the Product Space is noteworthy for its sparseness for an industrialized country. This is the result of very large export concentrations in three products – iron ore, coal, and natural gas – together with limited exports in a wide range of manufactured goods ranging from machinery to electronics to transport vehicles.

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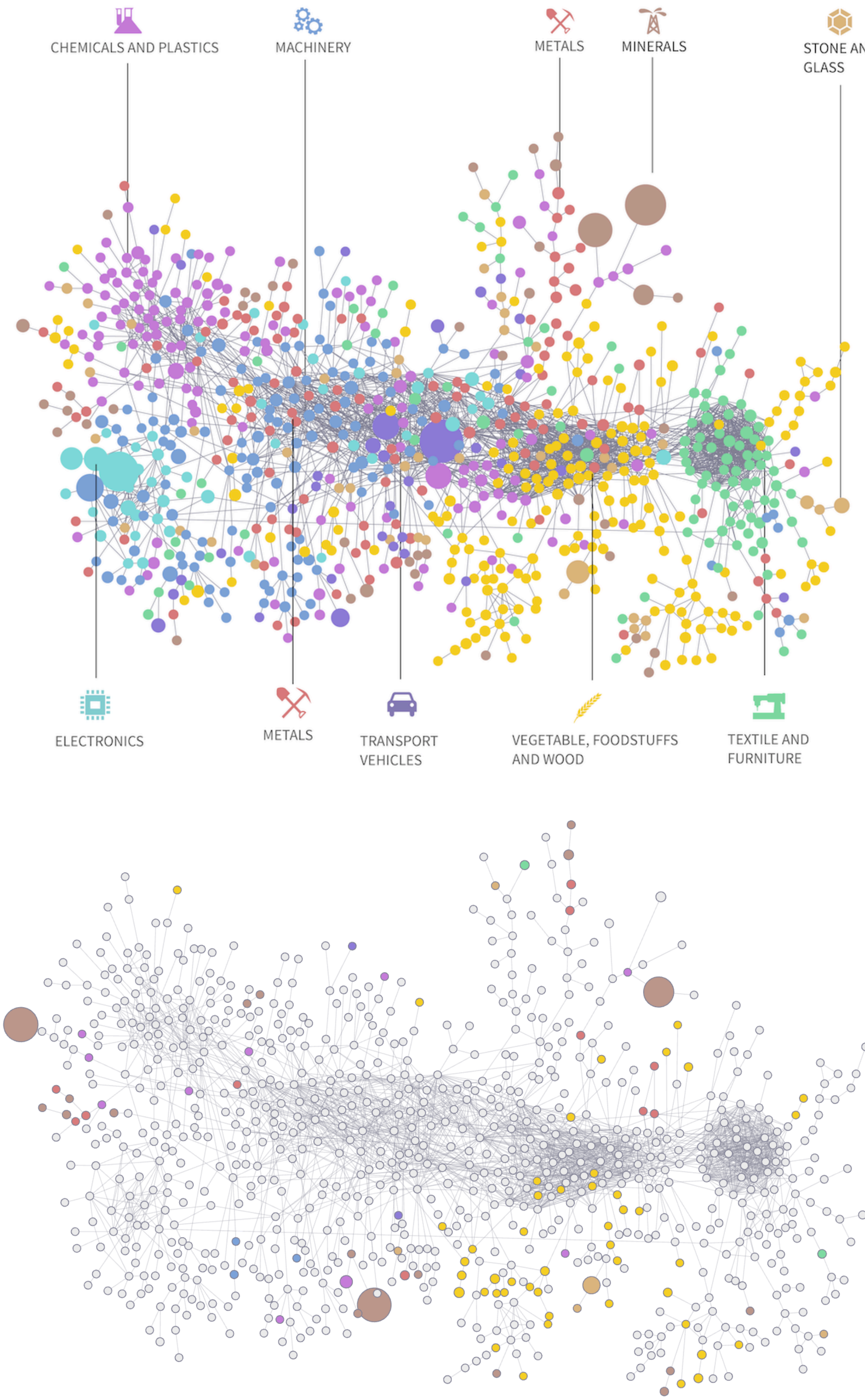
2 Harvard CID's Growth Lab developed a free, online tool for Product Space analysis of any country in the world. See http://atlas.cid.harvard.edu/.

Figure 2: Product Space with All Products (Top) and Australia's Products (Bottom)



Note: Circle size in top figure weighted by world trade; in bottom figure weighted by Australia's export value.
Source: Atlas of Economic Complexity

Box 1: Main Concepts in Economic Complexity

A description of several of the main variables in economic complexity methodology follows. It is important to bear in mind that apart from Revealed Comparative Advantage (RCA) and diversity, all these measures are normalized indices that carry **ordinal** but not necessarily **cardinal** meaning. That is, the order of values may matter, but it may be meaningless to interpret the precise numerical value of an index. For instance, if one product has a higher Product Complexity Index value than another it likely requires more specialized knowhow that is more useful for economic diversification. But one ought not to read too much into the precise numerical values of these indices. For example, if one economy's COI is double the magnitude of another that does not imply the former will diversify at twice the rate of the latter or find diversification twice as easy. For simplicity, these concepts are explained in terms of products, but, as the next sections will make clear, they apply equally for services as well.

* ***Revealed Comparative Advantage (RCA)*****:** This is a place-product measure that captures the relative importance of a product in a place. Following the methodology of Balassa (1964), it is usually calculated as the ratio between the proportion of the product in the export basket of a place and the proportion of the product in world trade. If this relationship is greater than one, the place has a "revealed comparative advantage" in that product, which is equivalent to saying that the place produces the product more intensively than the rest of the world. When the RCA is greater than one, this may also be referred to as an "MCP" (which is jargon that stands for "Matrix Country Product").
* ***Diversity*****:** This is a place-specific measure that is simply the total number of products or industries for which a place has an RCA greater than one. This is therefore very similar to the colloquial meaning of the word, but in this and other complexity reports diversity captures a measurable quantity that can be compared from one place to another. The diversity of a place captures how many different economic activities are present but does not have anything to say about the sophistication or the complexity of those activities. Higher diversity tends to be better for an economy because it implies less concentration in a few activities that can experience a negative shock at the same time. It also tends to be better for individuals because it implies more freedom to pursue different career opportunities.
* ***Product Complexity Index (PCI)*****:** This is a product-specific measure that ranks the diversity and ubiquity of the productive knowledge required for its production. It is determined by the average diversity of countries that make the product, as well as the average ubiquity of the other products that these countries make. The most complex products (that only a few, highly complex countries can produce) include sophisticated machinery, electronics and chemicals. Meanwhile, the least complex products (that nearly all countries, including the least complex can produce) tend to be common agricultural products and some raw materials.

* ***Economic Complexity Index (ECI)*****:** This is a place-specific measure that captures how complex a place's export basket is. It is calculated as the average PCI of those products in which the place shows an RCA equal or greater than one. Therefore, it reflects how much productive knowhow a place possesses. The most complex countries (that are highly diversified and able to produce products that only a few, highly complex countries can produce) include Japan, Switzerland, South Korea, and Germany. Meanwhile, the least complex countries (that are concentrated in few products that most countries in the world can produce) include Guinea, Angola, Burkina Faso, and Nigeria. ECI should not be confused with diversity; while diversity is the number of products in which a place has an RCA greater than one, ECI takes into account the PCI of each of those products.

* ***Distance*****:** It is a place-product measure and corresponds to the sum of the proximities connecting a new good to all the products that country is not currently exporting. This value is normalized by dividing it by the sum of proximities between the new product and all other products. In turn, proximity is a product-product measure that is calculated as the minimum conditional probability that a country intensively exports one product given that it already intensively exports the other. Thus, if a country exports most of the goods connected to a product, then its distance to it will be short (close to zero). However, if the country only exports a small proportion of them, then its distance to it will be large (close to one).

* ***Complexity Outlook Gain (COG)*****:** It is a place-product measure that quantifies the extent to which adding a new product to the current export basket can open up links to more, and more complex, new products. A high COG implies that a product is in the vicinity of more new products and/or of new products that are more complex, while a low COG means that a product is near many existing products and/or new products that are less complex.

* ***Complexity Outlook Index (COI)*****:** It is a place-specific measure that evaluates the overall position of a place in the Product Space by calculating how far it is to alternative products and how complex these products are. A high COI implies that the place has an easier path towards greater levels of complexity, while a low COI means that achieving them will be more difficult as it implies moving into products that are further away.

b) The Application of Economic Complexity Methodology to Western Australia

As a state with an economy dominated by mineral and mining-related activity, Western Australia has much to gain by applying the concepts of economic complexity to understand its existing capability set and to expand its comparative advantage. Prior to the impacts of the COVID-19 pandemic, the state economy was rebounding from a significant and extended slowdown in construction related to the mining sector, which has had reverberating negative effects on labor market outcomes, the health of the housing market, and the state's finances. Such slowdowns, and larger boom-bust cycles are a risk faced by under-diversified economies like that of the state. This analysis aims to help understand ways that state can accelerate economic diversification such that residents gain more from boom periods and so that job opportunities are more resilient to the bust. In order to take full advantage of this analysis, it is crucial to emphasize some important nuances concerning how economic complexity methodology fits into the Western Australian context.

First, it must be again emphasized that all discussion of "complexity" specifically refers to a place's or economic activity's tacit knowledge that is useful for economic diversification. This is a technical term that may not correspond with how one might conceptualize "complexity" in common discussion – such as logistical or technical sophistication. It is critical not to automatically assume an economic activity is "complex" simply because it appears to be logistically or technically sophisticated. For example, there is a burgeoning off-grid solar energy industry in Sub-Saharan Africa, in which many families use mobile money to access electricity from solar panels. This process certainly uses technologically sophisticated tools, but these tools are largely imported from developed countries and then simply used locally as is – without deep practical comprehension of their operating principles. This economic activity does not require or impart a great deal of complex tacit knowledge and cannot be considered a driver of knowhow required for economic diversification.

Second, it is useful to understand economic diversification in Western Australia in terms of complexity – that is, building on and expanding tacit knowledge. This should be especially contrasted with the common but misguided perspective that economic diversification is about value addition to a place's raw materials. Complexity is grounded in real patterns of global economic activity that show that diversification happens through places adding to their capability set as opposed to their raw materials. When diversification is thought of as adding value to raw materials, the scope of what is deemed possible is extraordinarily limited. In reality, high value economic activity is about adding value to *any* materials – not just those which are produced locally. Access to raw materials is only as far as a place's nearest port.

Third, it is important to keep in mind that higher economic complexity helps an economy to move into new products, but economic complexity is not a magic bullet for every economic problem. It is entirely possible for a country to produce a wide variety of highly complex products but still experience any number of issues ranging from micro-level regulatory deficiencies to macro-level monetary or fiscal imbalances, which can structurally hamper its growth. By the same token, some forms of economic production may not enable economic diversification but still be eminently useful in other ways. Western Australia's iron ore boom, for instance, was a critical factor which supported Australia through the Global Financial Crisis, even if it did not lead to much economic diversification.

Fourth, the goal of applying the economic complexity methodology is not to halt or replace any part of economic activity, but to build on it. Economic complexity is about enabling diversification through the accrual of knowhow in the economy, and for this purpose one should not seek to destroy knowhow. Economic complexity must thus be viewed as a tool to expand upon Western Australia's existing modes of economic production. It must absolutely not be viewed as a method of displacing Western Australia's current forms of economic production, as that would be inaccurate and counterproductive.

Western Australia's mining and minerals sector should be understood in light of the above discussion. Mining activities can certainly be logistically sophisticated and use high-end technology, but economic complexity methodology empirically finds that mining activities tend to have very low complexity. In other words, the sector on the whole tends to create few capabilities that lead to economic diversification. Critically, this does not mean that mining and minerals should be viewed negatively or that the aim of a complexity analysis is to replace mining and minerals. The sector is crucial to the state's economy and has provided many benefits to its population. It merely means that this report strives to identify opportunities that can grow alongside mining in the WA economy to diversify job opportunities and better position the economy to be more resilient to boom-and-bust cycles. Additionally, the analysis does not restrict itself to exploring opportunities for downstream production from mining and minerals, which would be highly limiting. In fact, by evaluating the tacit knowledge that exists in Western Australia, this report finds a much wider spectrum of opportunities than commonly assumed.

c) Adjustments to Conduct Complexity Analysis at State and Substate Level

Significant technical hurdles had to be overcome to conduct economic complexity analysis for Western Australia. For completeness, this and the following sub-section provide an overview of the steps taken to overcome these hurdles. Readers without a technical background who are interested in jumping to the results of the analysis may prefer to skip over these to Section 3.

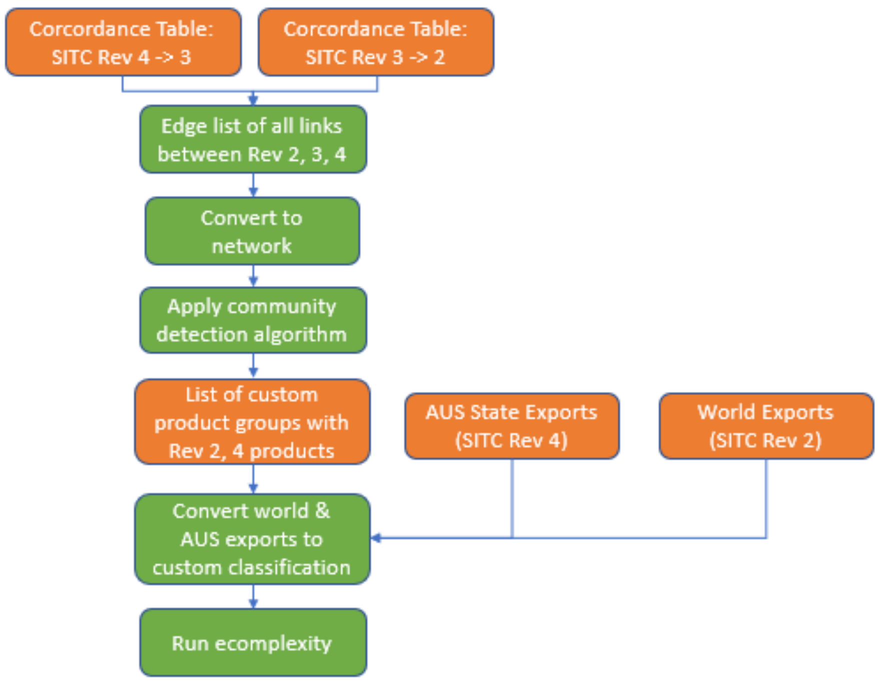
Traditionally, economic complexity analysis has been developed using export data at a country level. This is because international trade data provides a rich dataset with detailed information on the productive activities of most countries around the world over long periods of time, whilst using a standardized product classification. Therefore, to conduct complexity analysis for WA, exports data coded in the same classification system as available international trade data – either the HS 1992 or SITC Rev. 2 system – would be particularly useful to leverage international metrics of complexity. However, raw export data for WA is not available in either of these systems, and comprehensive substate-level exports data is wholly unavailable. As such, concordance and export prediction approaches were required to proceed with export analysis at the state and substate levels.

Once these concordance and prediction approaches are applied, it becomes possible to conduct export-based complexity analysis of WA, regions of WA, and Perth. For instance, one can examine ECI and COI scores for WA, and particular regions of the state, versus those for other Australian states or other countries. Importantly, all export data does not include services and only includes goods. After discussing the details of export-based data, we will later introduce employment-related data that includes service industries.

State-Level Exports Concordance

The availability of SITC Rev. 4 export data at the state level for WA makes international comparison relatively straightforward; the data need only be concorded with SITC Rev. 2, which is an older version of the same classification system. Given the similarity of SITC Rev. 2 and SITC Rev. 4, it is appropriate to apply Diodato's (2018) network-based concordance method. This procedure creates a custom classification system to which SITC Rev. 2 and SITC Rev. 4 can be optimally matched. A flowchart of the entire procedure is presented in **Figure 3.**

Figure 3: Flowchart for Concordance between SITC Rev. 4 and SITC Rev. 2



Source: Own construction

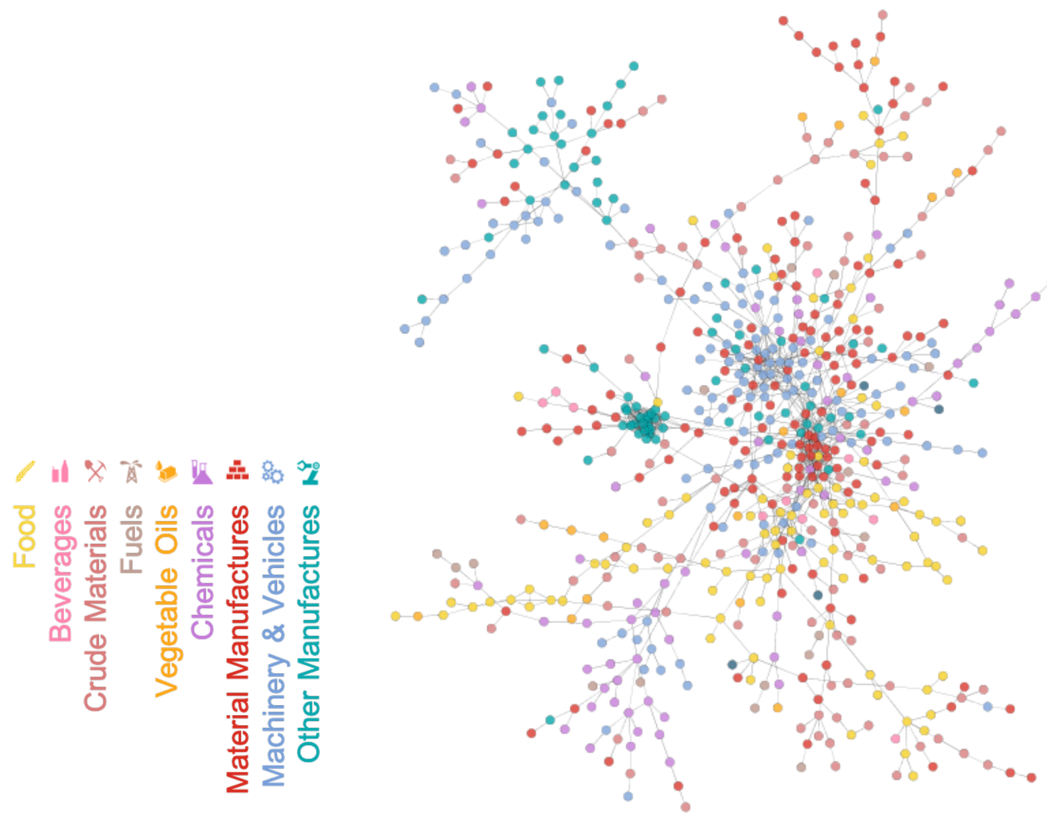
First, two concordance tables are obtained matching SITC Rev. 4 to SITC Rev. 3, and SITC Rev. 3 to SITC Rev. 2. For each product in the source classification system, a list of possible product matches in the target classification system is given. The two concordance tables are converted to an edge list, which lists all the links between each product across each classification scheme. This edge list is subsequently converted to a network format, where each product in each classification scheme is a node and edges connect nodes that match together.[3] To obtain appropriate groups of matching products from SITC Rev. 2 and SITC Rev. 4, a clustering algorithm is applied that identifies the most cohesive groups of products among larger communities of many connected products. This allows matching SITC Rev. 2 and SITC Rev. 4 products on a relatively granular

[3] In some cases, this creates disconnected communities where only a few products are connected, and in other cases, many products are connected together in a single large community.

level, even though the original network may have created large groupings.[4] The result is a table where each row is a relatively granular group of matching products, and the matching SITC Rev. 2 and SITC Rev. 4 products are listed for that row.

Having obtained this new classification scheme, which matches SITC Rev. 2 and SITC Rev. 4 products, trade data from Australian states (SITC Rev. 4) and the world (SITC Rev. 2), can be merged. The output is a database of trade data in a unified classification scheme that includes both world countries and Australian states. Importantly, this new classification scheme is unique and custom-made. It is not the same as any existing classification scheme, including those found on the CID's Atlas of Economic Complexity. Based on co-exports patterns of the products of this new scheme, it is possible to build an alternative, concorded, Export Space, shown in **Figure 4**.

Figure 4: Concorded Export Space



Source: Own construction based on ABS and COMTRADE

This custom-made export space allows us to analyze WA's productive capabilities for exportable goods in relation to not only other Australian states but also all other countries in the world. This

[4] Notably, however, these granular clusters may still include several SITC Rev. 2 and/or SITC Rev. 4 products; one might imagine this could occur if the products in question are all highly related.

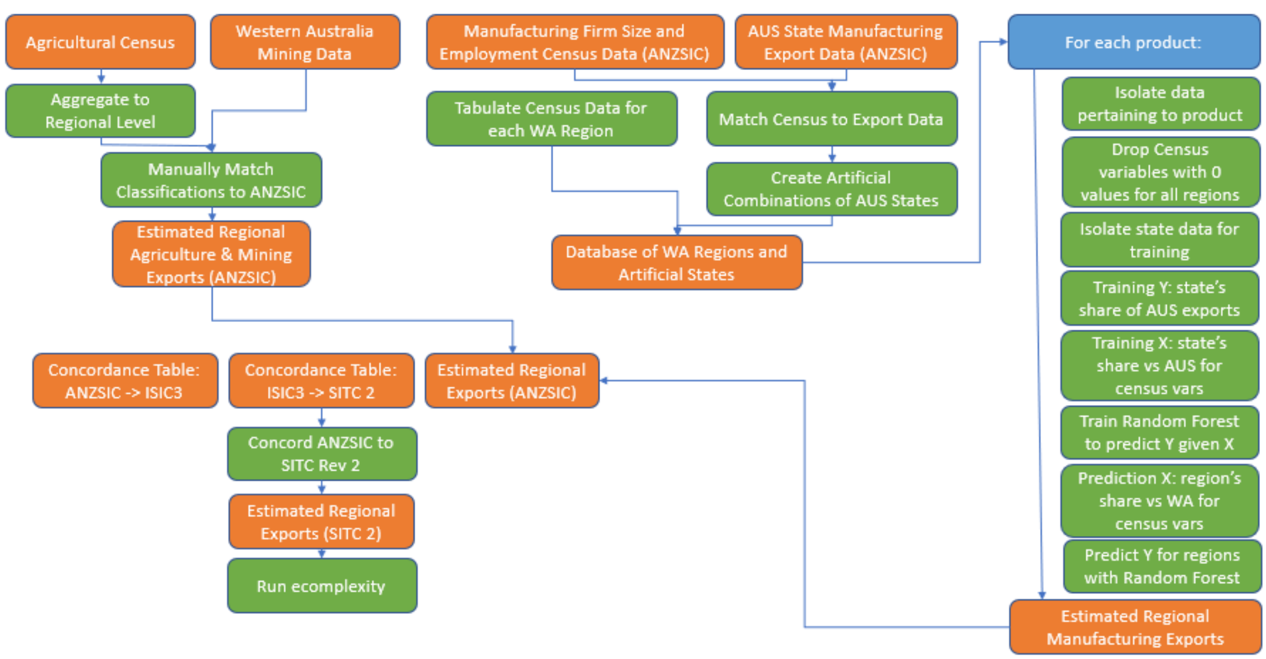
is important for understanding existing capabilities, both related to and unrelated to mining, and identifying promising paths to diversification.

Regional Exports Prediction

Exports by regional area of WA are substantially more difficult to obtain because there is no comprehensive data on regional manufacturing exports in any classification scheme. This requires a prediction approach, where available regional economic data is used to predict each region's exports. The algorithm for obtaining predicted regional exports is shown in **Figure 5**.

Agricultural and mining export data is manually matched to the ANZSIC classification scheme. Agricultural data is sourced from the Agricultural Census, which is aggregated to the regional level and then matched to ANZSIC. Basic data on WA mineral production is already available by type of mineral at the regional level. This is matched to ANZSIC as closely as possible, considering ANZSIC-coded state-level exports by mineral and the total mining output by region. Notably, offshore petroleum is dropped from the analysis because it is especially problematic to match to any particular region.

Figure 5: Flowchart for Regional Export Prediction



Source: Own construction

A machine-learning approach is used to predict regional manufacturing exports. The analysis is predicated on the availability of ANZSIC-coded exports at the state level, and ANZSIC-coded employment (based on place of work, not place of residence, which avoids potential bias due to miscounting the geography of Fly-In Fly-Out workers) and firm size data at both the state and regional level. The goal of the algorithm is to predict a location's exports in a particular industry given its employment and firm count in that industry. This approach's strategy is to train the algorithm on state-level data for 2006, 2011, and 2016, and then use it to predict exports at the regional level for 2016.[5] Having trained the machine-learning algorithm on state-level data for a particular industry, it is then asked to predict each region's share of WA exports given its share of state employment (as measured by place of work, not place of residence) and firms. This procedure is applied iteratively until regional exports have been predicted for all manufacturing industries.

Regional estimates for agriculture, mining, and manufacturing exports under the ANZSIC classification system are then converted to SITC Rev. 2. Given that this requires first concording ANZSIC to ISIC Rev. 3 and then ISIC Rev. 3 to SITC Rev. 2, a clustering approach to concordance is not appropriate because there are too many "many-to-many" (m:m) matches. In this case, using simple concordance tables, and accepting the associated imperfections of incomplete matching, yields better results. The output is a database of regional SITC Rev. 2 exports, which can be directly used with world SITC Rev. 2 export data.

This process allows for economic complexity analysis to be extended to regions within the state. Recognizing the imperfections of the machine-learning approach, it is important for region-level findings to be complemented by widespread stakeholder interaction at the region-level to put results in context and extract value for policymaking.[6]

d) Adjustments to Incorporate Services in the Analysis

Given the lack of standardized export data for services with sufficient industrial disaggregation at an international level, economic complexity analysis has traditionally focused exclusively on goods. This has the major limitation of ignoring patterns of diversification in services, which is of increasing importance as services are growing faster globally than is manufacturing. In order to account for this gap, we adapt a recently developed approach to perform complexity analysis inclusive of services used by CID in previous projects, such as Jordan (Hausmann, R., et al., 2019) and Buenos Aires.

Previous efforts to incorporate the service sector within the complexity framework were made by Hausmann, Morales and Santos (2016) in Panama, taking advantage of the comprehensive nature

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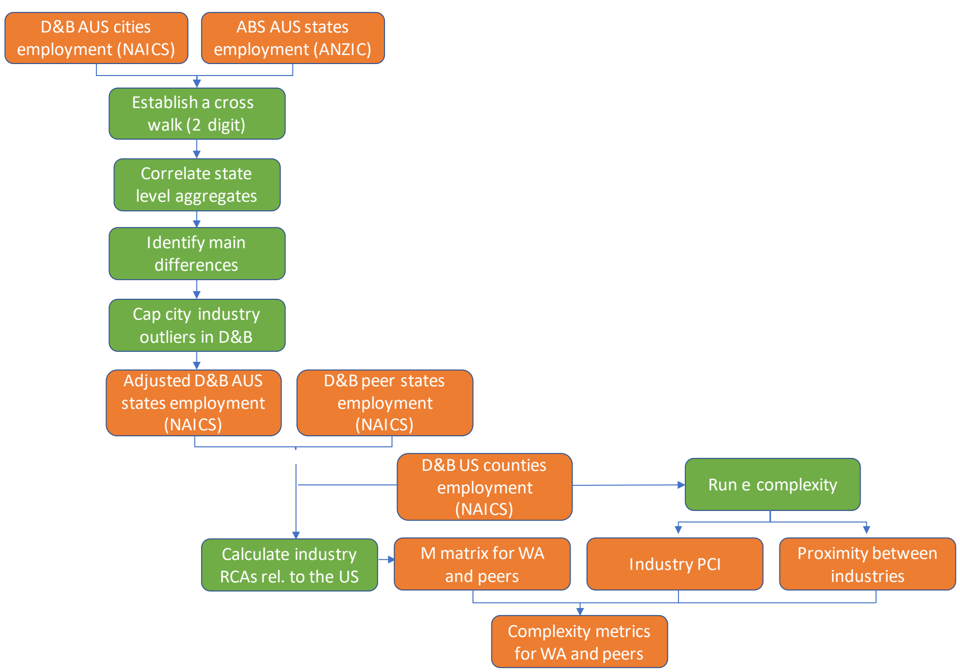
[5] For the training procedure, each state's exports, employment count, and firm size in a particular industry are expressed as a share of the national total. Combinations of states are then generated to create new, synthetic states. This generates additional data points spanning a wide range of export shares, which ultimately increases the accuracy of the machine-learning algorithm. The training algorithm considers one particular industry at a time. After isolating a particular industry, it drops all input variables concerning employment and firm count that are zero for all regions. This ensures that the algorithm will not train on input variables that are not informative at the regional level. A random forest machine-learning algorithm is then trained to predict each state's share of national exports, given its share of national employment and firms.

[6] The research team conducted brief stakeholder meetings in six regions of the state, including Perth, during the week of March 9-13, 2020 and verified that this method effectively identified numerous important trends across regions of the state. Regional Development Commissions and other knowledgeable institutions will be important for extracting maximum value from this analysis.

of the population census in that country. Other attempts at representing a product space including services are to be found in the Colombian Atlas of Economic Complexity and the Mexican Atlas of Economic Complexity. In turn, these online tools have supported numerous efforts to identify productive capabilities at the sub-national level and the most attractive opportunities for structural transformation including goods and services. However, unlike most of the examples described, in the case of WA it seems desirable not to limit references to other states in the same country, but also to include states in other parts of the world.

In order to satisfy this aspiration, we use the Dun & Bradstreet (D&B) database, which has representative employment information with broad international coverage and high geographical and industrial disaggregation for both goods and services from the year 2019. In doing so, some significant cleaning of the data and adjustments to the original methodology were required. A flowchart of the entire procedure is presented in **Figure 6**.

Figure 6: Flowchart for Incorporating Services to the Complexity Analysis



Source: Own construction

An initial challenge was that the level of correspondence between the raw data regarding the number of employees by sectors at a state level coming from D&B and that published by the Australian Bureau of Statistics (ABS) is low, in terms of both level and composition. Importantly, the differences observed are strongly concentrated in a small number of cities and industries. With this in mind, we developed a method to systematically deal with the existence of these outliers (errors) in the D&B data. For this purpose, we distinguish between prevalent industries (which one would expect to find in any city, such as supermarkets) and rare industries (which naturally tend to concentrate in a few places, such as mining). The objective is to establish a different criterion for defining an outlier in both cases, which would be more demanding in the second case than in the first.[7] Our methodology only caps extremely high values, modifying a very limited share (0.60%) of all city-industry combinations. These few changes were enough to bring aggregate figures much closer,[8] allowing us to make use of (adjusted) D&B data for our analysis.

Once this cleaning step was completed, certain methodological adjustments were needed in order to use employment information instead of export data to capture the relative intensity of different economic activities. This employment-based analysis utilizes the same concept of RCA as the export-based analysis but uses employment totals rather than export values to measure relative intensity.[9] In the export-based approach, the reference has always been the entire world. This is possible because international trade data is comprehensive and representative of all countries and products. Unfortunately, with all its advantages, the D&B does not meet this standard as it shows low levels of representation for many countries. So instead we chose as a reference the United States, as the country has the highest level of coverage at the sub-national level in the D&B database and is located at the technological frontier.

We also use the D&B data from the U.S. to calculate the complexity of different industries (PCI) and the proximity between industries. For this purpose, we focus on employment by industry at the county level. The selection of counties as the analysis unit has the important advantage of allowing a sufficient degree of variability and maximizes the criteria of "nestedness" versus other units of analysis (state-level and establishment-level). In other words, this analysis yields a strong inverse relationship between the diversity of counties and the average ubiquity of industries intensively present in them. **Figure 7** shows the Employment Space that results.

This custom-made employment space allows us to explore WA's productive capabilities including both goods and services. It has the advantage of providing a highly granular industry disaggregation that allows us to explore connections between all industries, goods and services alike. However, it does have several limitations. First, the data source does not allow us to observe changes in productive capabilities over time. Second, we are not able to compare the state's position with all other places, without checking for representativeness and doing appropriate cleaning for comparator states. Third, the intensive presence of an industry in this space can

7 For each (6-digit NAICS) industry, we sort Australian cities according to the number of employees they have in that industry and calculate the 95th percentile. If this value is greater than 0, we say that is a prevalent industry and, if it is 0, we say that it is rare. For prevalent industries, for all cities above the 95th percentile, we calculate the ratio of employees to this value. We then cap the number of employees at the 75th percentile of this ratio times the 95th percentile calculated earlier. In the case of rare industries, first we calculate the median number of employees of all cities with a positive value (by definition, less than 5% of all cities). Next, for all cities above the median, we calculate the ratio of employees to this value. Finally, we cap the number of employees at the 75th percentile of this ratio times the median.

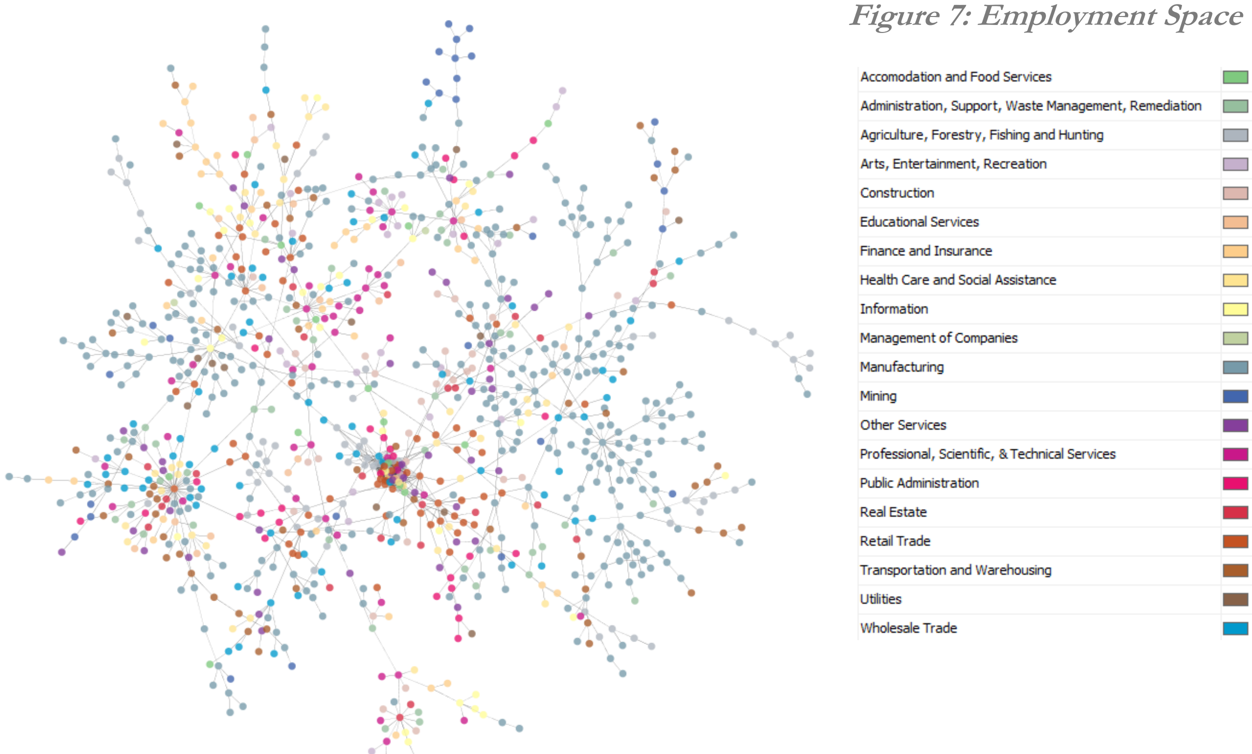
8 For the correlation of the division employment at a state level between ABS and D&B data, excluding the Northern Territories state and the agriculture and public administration sectors, increases from 57% to 90%.

9 Therefore, it implicitly assumes that the combination of capital and labor used to develop a certain industry is relatively similar in all places.

sometimes indicate very high local demand for a (non-tradable) service rather than especially competitive capabilities to produce the service. Fourth, the data counts employment based on each firm and its listed location, which in some cases may be the firm's headquarters instead of its place of operation.

The last of these data limitations is especially important because of the prevalence of Fly-In Fly-Out (FIFO) work in WA. This creates a bias towards mining-related employment being counted in Perth instead of the regions. In principle, this could lead to the understatement of the relative importance of non-mining industries in Perth. It could also lead to the understatement of the relative important of mining industries in the regions.

Figure 7: Employment Space



Source: Own construction based on D&B

For these reasons, we use this space together with the export space throughout the analysis that follows. The export space is less granular but allows for comparisons over time and more widely against countries; and in addition is far less likely to suffer from bias related to miscounting the geography of FIFO workers. Additionally, since in order to export a good a place must be globally competitive, the export RCA also provides a stricter measure of supply-side capabilities as opposed to demand. Using the two approaches of export-based complexity and employment-based complexity in parallel allows us to develop a rich understanding of productive capabilities and diversification opportunities in the state.

Wherever we compare employment-related complexity measures of WA versus other places, we focus these comparisons on a select group of "peer states," which were chosen through a careful methodology that is detailed in Annex 1.[10] In developing criteria for the selection of peer states, we explicitly aim to find states that are similar to WA on several dimensions (including income per capita, population of state, population of the largest city, population density, remoteness, and similarity of employment profiles) and that have quality representation in the D&B dataset. It is most useful for the peer group states to generally have higher levels of economic complexity than WA because this can be helpful in identifying diversification pathways that have yet to emerge in the state. When this is achieved, the peer group will include other states that can be thought of loosely as "role models" for diversification. This feature of the group is achieved with the list utilized, and Annex 1 explores how the peer group list could change with different thresholds applied to the selection criteria. The inclusion of the state of California may at first appear out of place because of how much bigger the state is in terms of population and economic activity, but it serves a very important role as a long-term role model. In fact, there are striking similarities between the California and WA, especially if one looks back in time. One hundred years ago, California was a much more remote state with a population similar to that of WA today. Despite also being a water-scarce state, its population grew over time with its economy, which made it increasingly less remote.

[10] Peer group states selected by our methodology are New South Wales, Victoria, and Queensland (Australia); Alberta, British Columbia, Ontario, and Quebec (Canada); Hokkaido (Japan); Arizona, California, Colorado, Nevada, Oregon, and Washington (USA).

3. Analysis of Current Capabilities

This section is divided into two parts. First, WA's economic structure is profiled to shed light on important sectors and trends. This will mostly be done without applying economic complexity metrics in order to provide context. Second, WA's economy complexity is analyzed with use of the employment and export spaces and related measures to better understand productive capabilities and potential for economic diversification.

The export and employment approaches described above are used in parallel. Each approach has its own advantages and disadvantages, and they are consequently complementary. The exports approach uses a more demanding standard for establishing comparative advantage and allows us to evaluate the evolution of variables (exports, diversity, complexity, etc.) over time, but is restricted in scope to goods exports. On the other hand, the employment approach allows us to include service and non-tradable sectors and compare WA with subnational entities in other parts of the world, but given data limitations it can't be analyzed over time.

a) Economic Structure of Western Australia

Despite representing a relatively small share of Australia's total employment, WA is a major export player.

WA accounts for nearly 11% of Australian employment, which is roughly in line with the state's share of national population. However, goods exports from the state represented 46% of the national total on average over the period 2008-16. As shown in **Figure 8**, the state's goods exports increased by approximately 50% between 2009 and 2013, reaching a peak level of USD 110 billion. Between 2013 and 2015 they fell sharply, returning to 2009 levels. Over the whole period, WA's annual goods exports averaged USD 87 billion, by far the largest for all states. In fact, WA's exports were, on average, 2.4 times the exports of the second largest exporter, Queensland. Its exports per capita, unsurprisingly, were accordingly high. These averaged $36,000 USD and peaked at nearly $49,000.

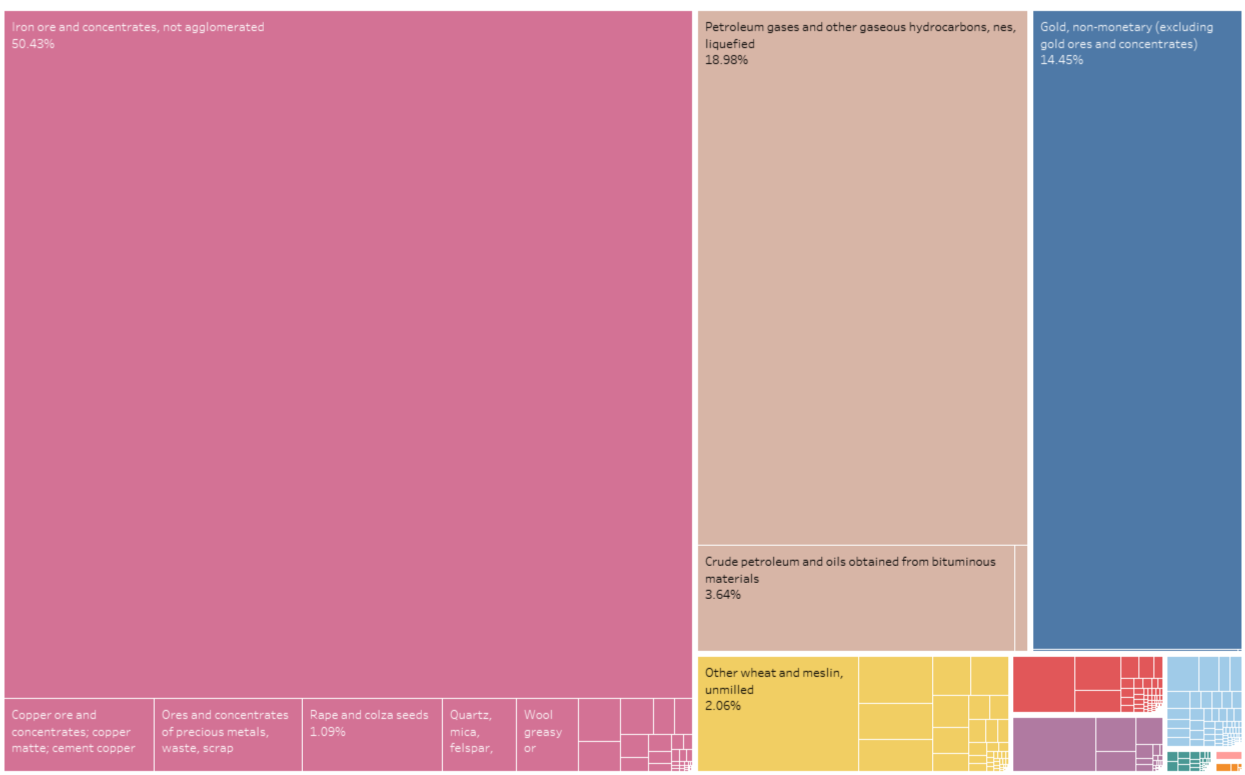
Figure 8: Australian States Total Exports – Evolution and Destination

Source: Own construction based on ABS and COMTRADE

WA's economic structure is particularly intensive in raw materials (namely mining and natural gas) and related industries.

WA's exports are dominated by raw materials, which accounted for a large majority of goods exports in 2016 (**Figure 9)**. Iron ore was particularly important, accounting for more than 50% of goods exports on its own.

Figure 9: Western Australian Exports by Share, 2016

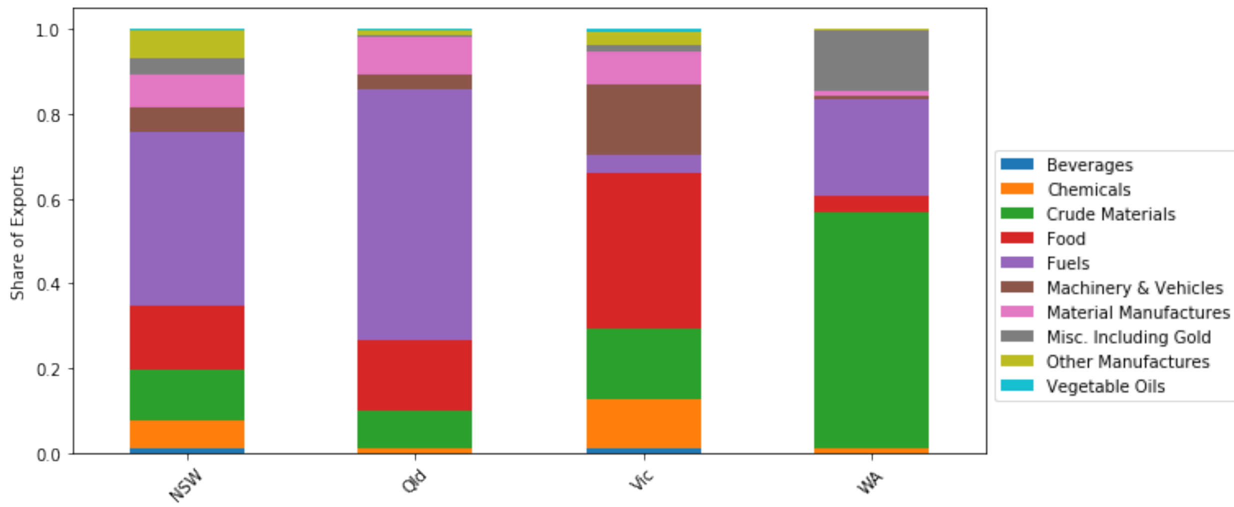


Source: Own construction based on ABS and COMTRADE

This degree of export specialization in is unusual by Australian standards. As shown in **Figure 10** no other large Australian state had such a high share of exports attributable to crude materials in

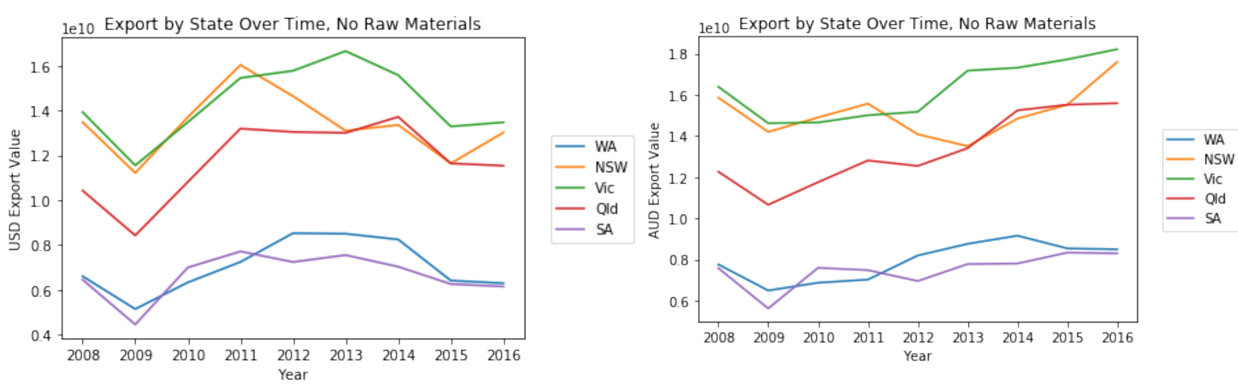
2016 (although some other states were instead intensive in fuels exports). These materials explain much of WA's outsized role in national exports. If crude materials are excluded, WA's exports from 2008-2016 average 7 USD billion (**Figure 11**), a level comparable to that of South Australia and roughly half the size of exports from other large Australian states.

Figure 10: Share of Exports by Sector, Selected Australian States



Source: Own construction based on ABS and COMTRADE

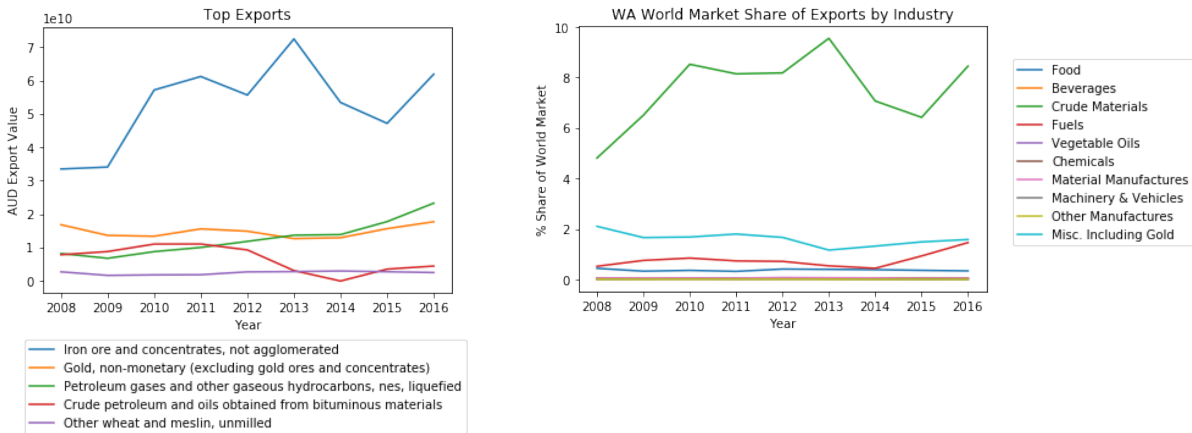
Figure 11: Non-Raw Material Exports by Australian State



Source: Own construction based on ABS and COMTRADE

WA's concentration in crude material exports in general, and iron ore in particular, has increased over time, even with a slowdown in iron ore exports between 2013 and 2015 (**Figure 12**). Iron ore exports in AUD increased by 84% overall between 2008 and 2016. Over this period, the state nearly doubled its global market share of crude material exports but stagnated in other product categories, with the exception of fuels since 2014.

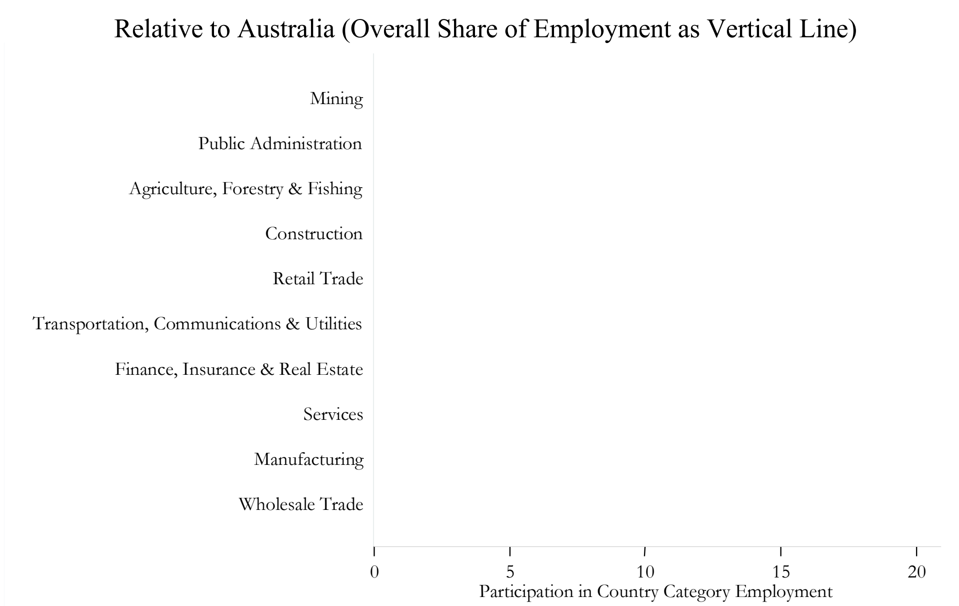
Figure 12: Top Exports by AUD Value and World Market Share by Industry



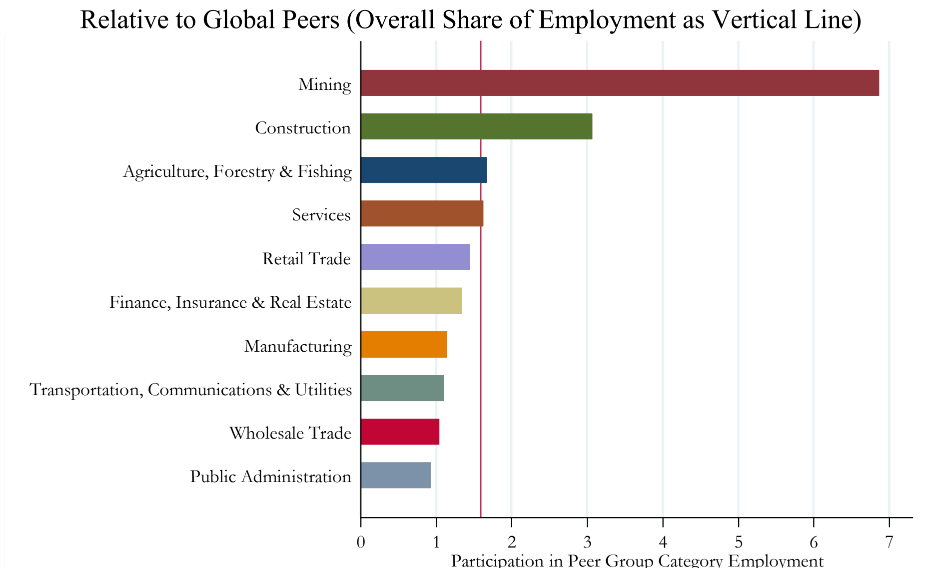
Source: Own construction based on ABS and COMTRADE

WA's employment profile likewise strongly features mining. **Figure 13** shows WA's employment in various NAICS-coded industries as a share of total employment in large Australian states and the peer group as a whole. WA's share of employment in mining is high compared to other Australian states, and very high compared to international peers. Over 16% of mining jobs in Australia are in WA (in comparison to less than 11% of jobs overall) and almost 7% of mining jobs in the peer group are in WA (as opposed to approximately 1.5% of jobs overall).

Figure 13: WA's Share of Employment in Australia (top) and over the Peer Group (bottom)[11]



[11] Note that "Services" includes all services not explicitly identified by other categories.



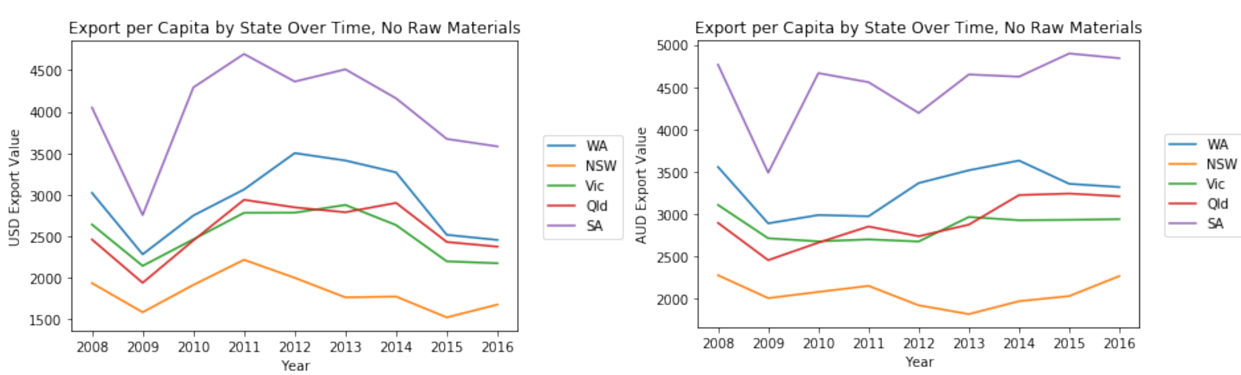
Note: The red line denotes WA's overall share of employment (including all categories)
Source: Own construction based on D&B.

Figure 13 also shows that WA has a relatively high number of jobs in construction and a relatively low number of jobs in many sectors (including public administration; wholesale trade; transportation, communications and utilities; and manufacturing) in comparison to the peer group. Interestingly, the employment profile is much more aligned with other Australian states.

WA's non-mining economy strongly features construction and agriculture and has some footholds in manufacturing.

Whereas WA's total goods exports per capita are very high, its non-raw material exports per capita fall within a normal range compared to other Australian states (**Figure 14)**. WA's non-raw material exports per capita ranged between USD 2,200 and 3,500 over 2008-16, similar to the levels of Queensland and Victoria, and well above that of New South Wales.

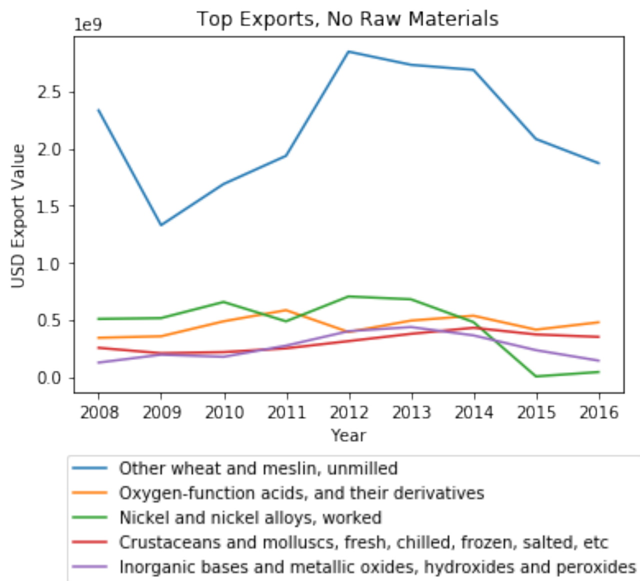
Figure 14: Non-Raw Material Goods Exports per Capita by State



Source: Own construction based on ABS and COMTRADE

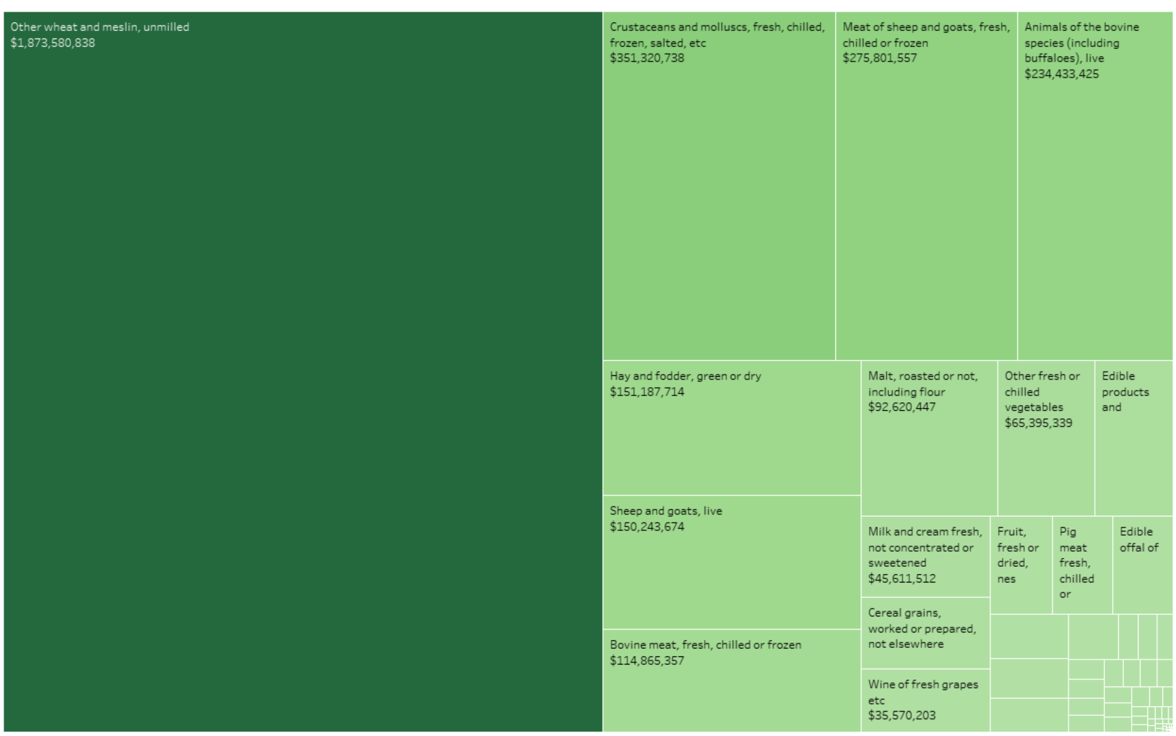
WA's non-raw material exports are dominated by wheat (**Figure 15)**. Nevertheless, it exports a number of agricultural products in large volumes (**Figure 16**). Significant agricultural exports in 2016, other than wheat, included crustaceans, cattle, sheep, beef, mutton, milk, and wine.

Figure 15: Top Non-Raw Material Exports for Western Australia



Source: Own construction based on ABS and COMTRADE

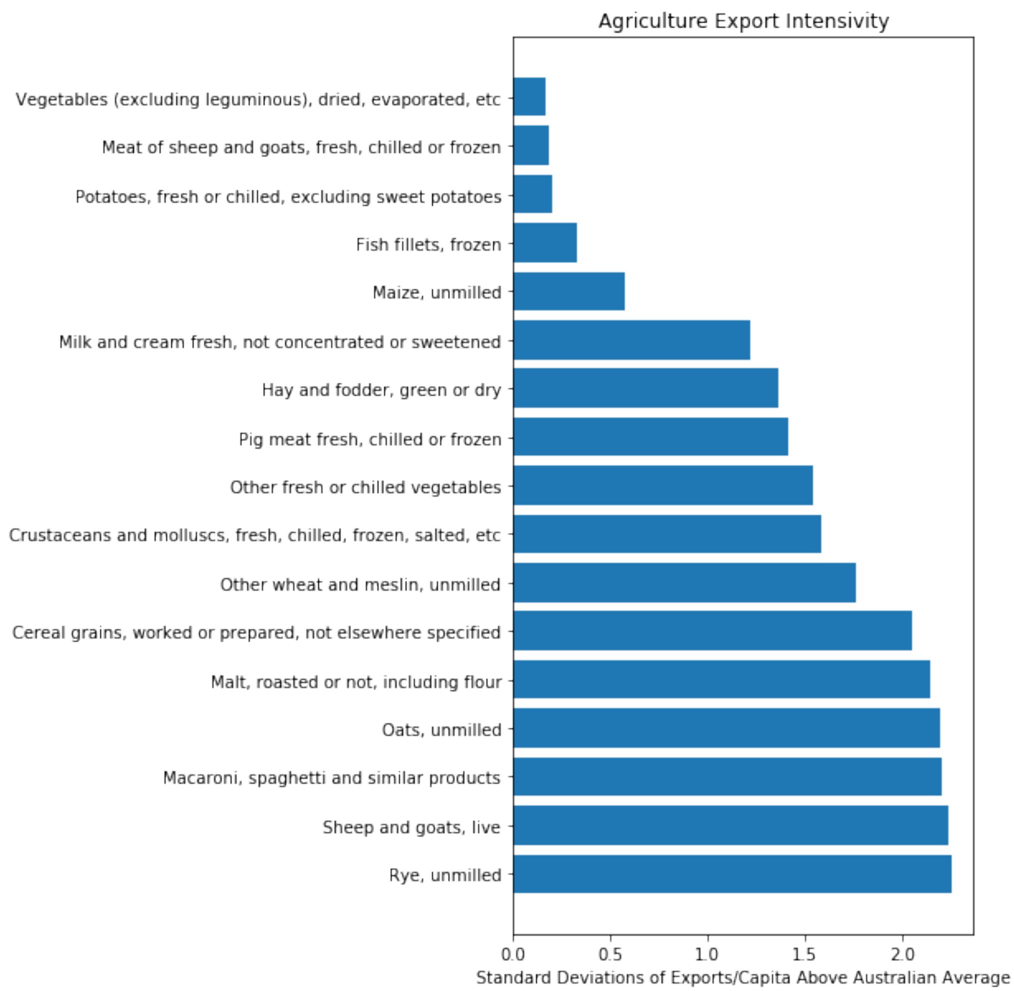
Figure 16: Western Australia's Agricultural Exports, 2016



Source: Own construction based on ABS and COMTRADE

In some cases, WA's agricultural exports per capita are substantially higher than what is found in other Australian states (**Figure 17)**. Examples include milk, pork, vegetables, cereal grains, and sheep. Although these agricultural exports outside of wheat are dwarfed in size by the mining economy, it is clear that WA has comparative advantages across a range of agricultural activities versus elsewhere in Australia.

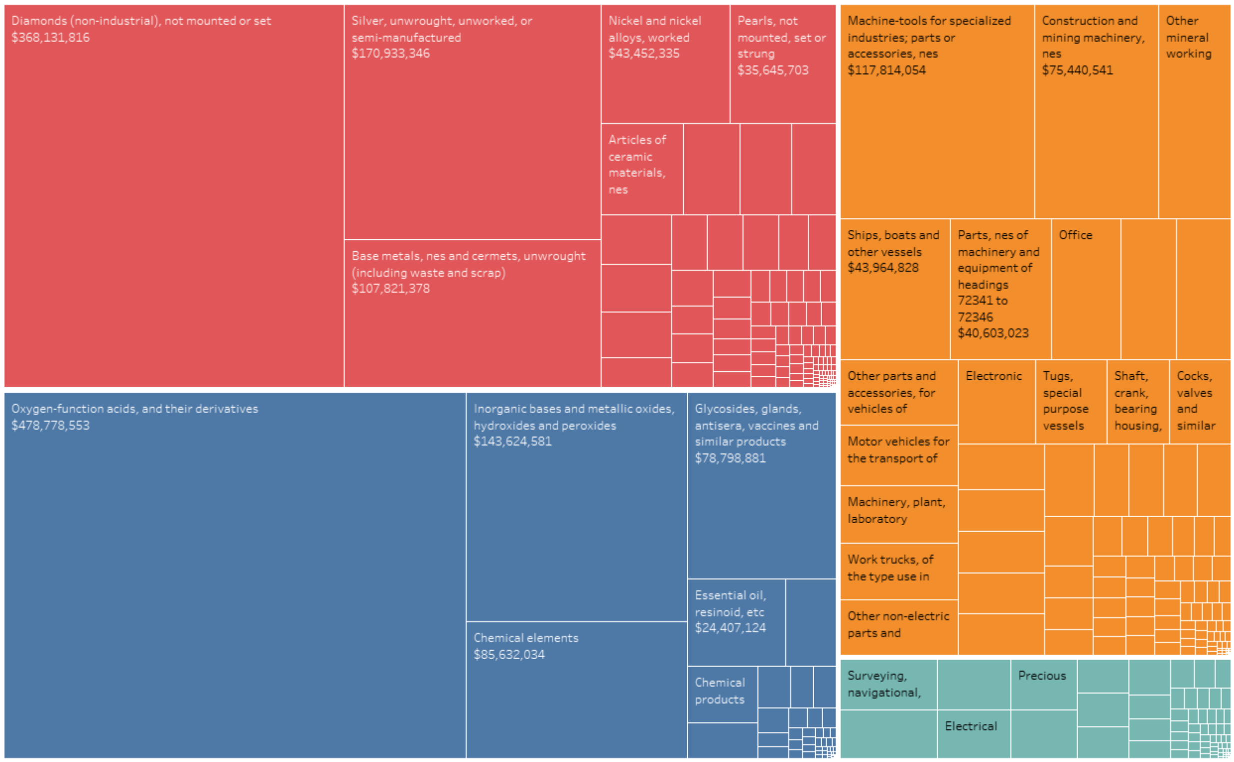
Figure 17: WA Agricultural Exports Above Australian Per Capita Average



Source: Own construction based on ABS and COMTRADE

While WA does not export manufactures on the same scale as minerals or agriculture, it does export some manufactured goods that in many cases appear to be related to the mining and construction industries. **Figure 18** shows WA's manufacturing exports in 2016. A number of chemical, material, machinery, and vehicle manufactures feature prominently, for instance nickel alloys, metallic oxides, construction and mining machinery, and work trucks.

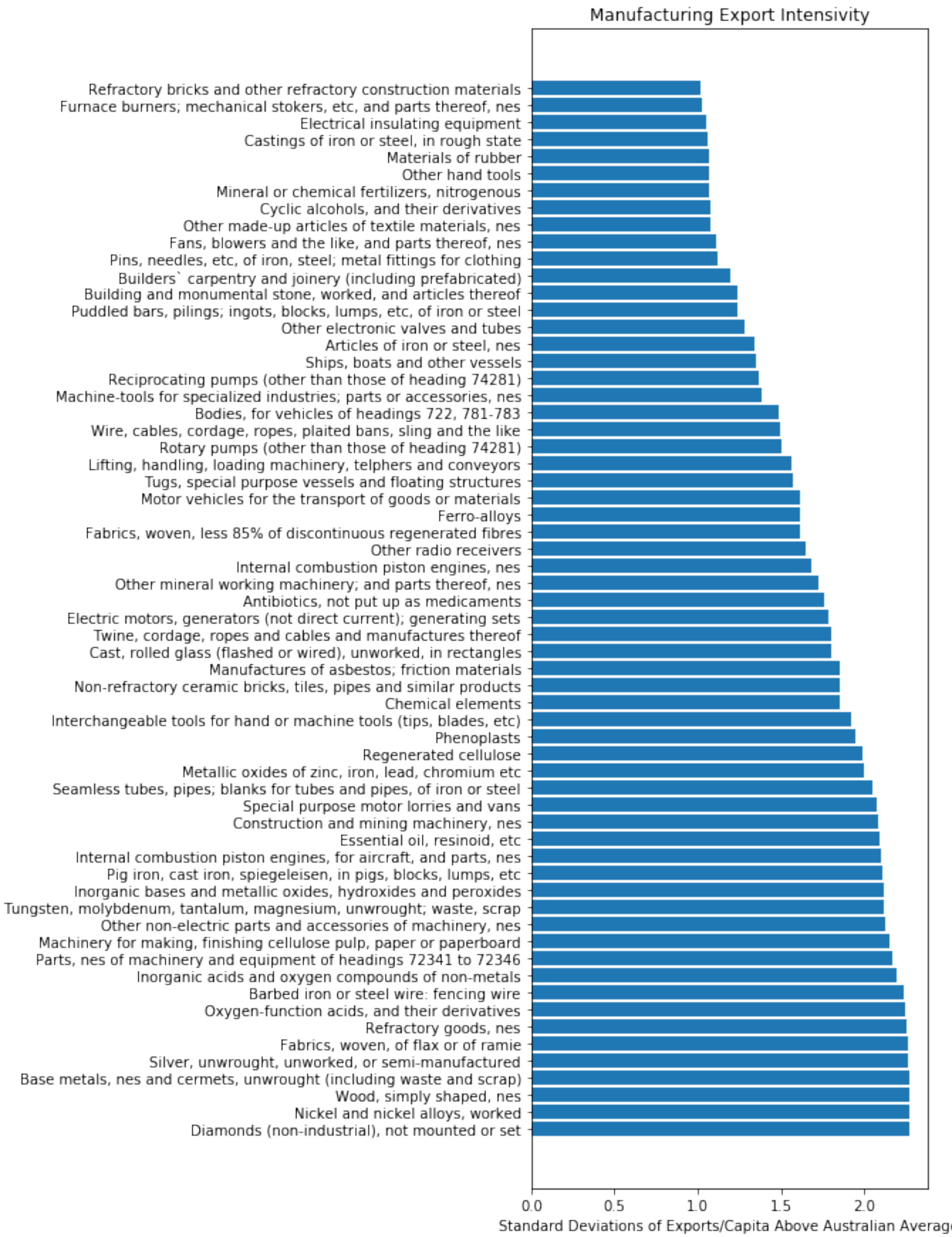
Figure 18: Western Australia's Manufactured Exports, 2016



Source: Own construction based on ABS and COMTRADE

In many cases Western Australia's per capita manufacturing exports substantially exceed levels found in other Australian states (**Figure 19**). While many of these industries are relatively small in terms of their volumes, their presence may be encouraging for future diversification efforts, since the list reflects a wide range of established capabilities to produce manufactured goods in at least some locations in the state.

Figure 19: WA Manufacturing Exports Above Australian Per Capita Average



Source: Own construction based on ABS and COMTRADE

WA's exports are dominated by demand from East Asia.

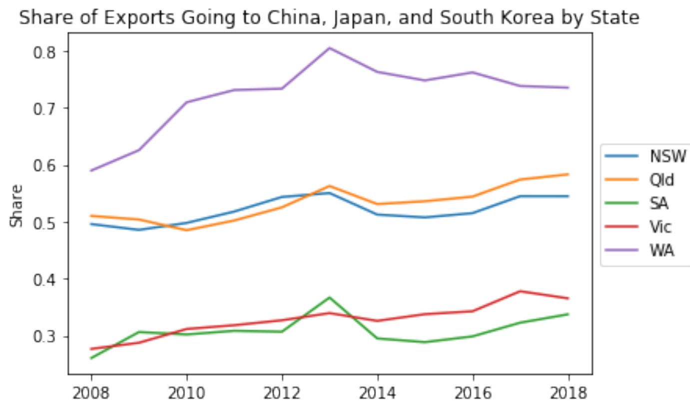
Over 75% of WA's exports have recently gone to just three destinations: China, Japan and South Korea (**Figure 20)**. This is a somewhat recent development, driven in part by the increase of exports destined for China (+39 billion over the last decade). In 2008, China-bound exports amounted to 30% of WA's exports (22 billion), while in 2018, they comprised approximately half of them (61 billion). WA's pattern of export concentration in these destinations is the highest among large Australian states, but these three destinations also play significant role in demand for exports from Queensland and New South Wales (**Figure 20)**.

Figure 20: Export Destinations by State and for Western Australia Over Time

Source: Own construction based on ABS and COMTRADE

Importantly, WA's concentration in Asia-bound exports has been persistently high and increasing compared to other large Australian states (**Figure 21**). As early as 2008, nearly 60% of WA's exports went to China, Japan, and South Korea, and this has now increased to more than 70%. This could be somewhat explained by the accelerated increase of iron ore imports in China, and the significant competitive advantages that WA displays to satisfy this demand.

Figure 21: Asia-Bound Exports by State Over Time

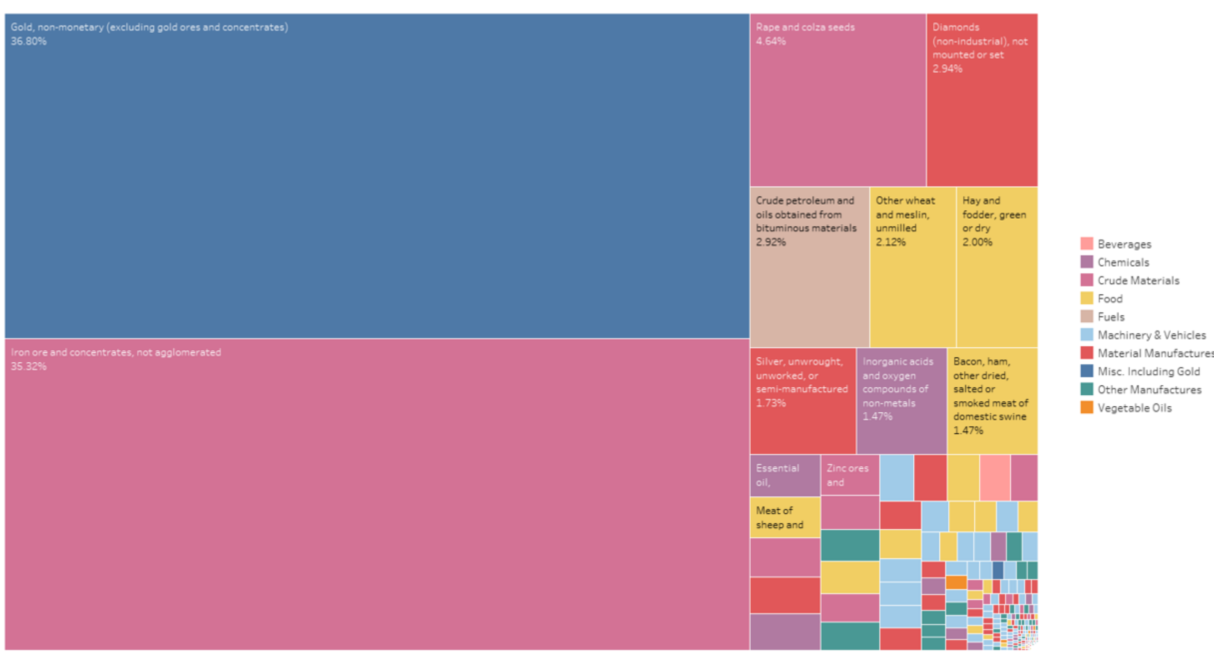


Source: Own construction based on ABS and COMTRADE

WA's exports to the developed world alone are less resource intensive.

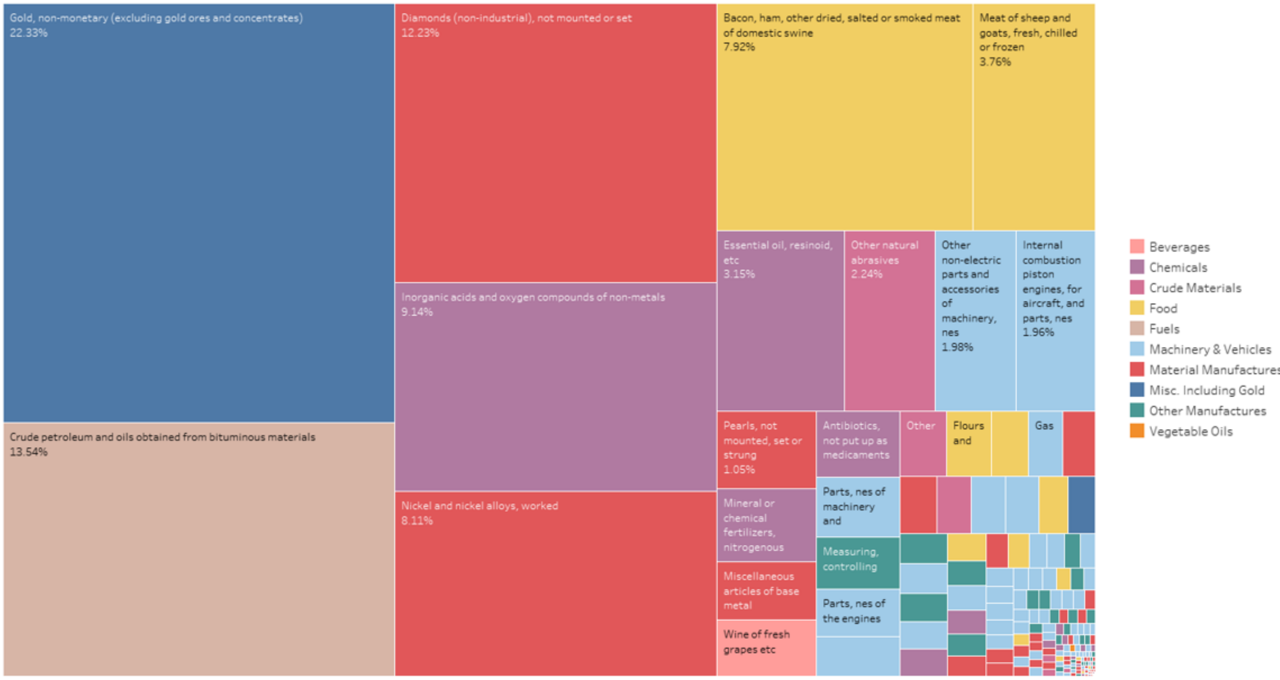
While mineral exports dominate overall goods exports from the state, their dominance is less pronounced when one looks exports bound exclusively for developed countries. While this still includes Japan and South Korea, it notably does not include China. **Figure 22** shows that OECD-bound exports in 2016 contained a noticeably higher share of agriculture goods and manufactures than is found in WA's overall export portfolio. **Figure 23** shows that exports bound for the US in 2016 were even less resource intensive. These could signal latent capabilities that would allow WA to be competitive in certain emerging sectors even at the innovation frontier.

Figure 22: WA's OECD-Bound Exports, 2016



Source: Own construction based on ABS and COMTRADE

Figure 23: WA's US-Bound Exports, 2016



Source: Own construction based on ABS and COMTRADE

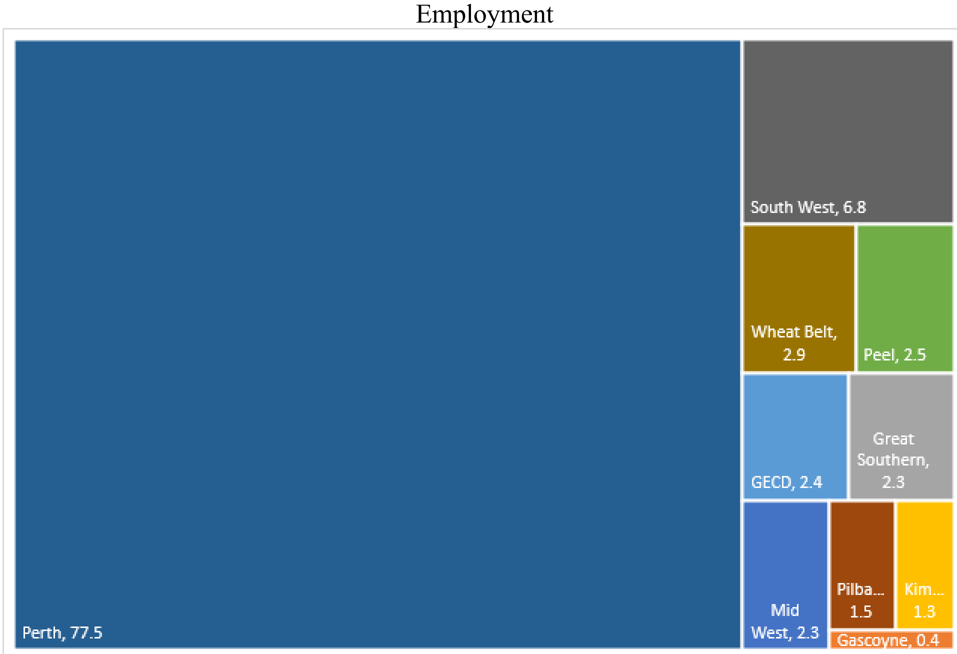
WA regions vary considerably in economic structure and scale.

WA is the second-largest subnational entity in the world by land area, has a large population living in Perth in addition to substantial rural settlement, and features a wide variety of climates. Unsurprisingly, its regions thus have considerably varied economic structures. Perhaps the most obvious differences are in terms of scale (**Figure 24**). Nearly 80% of the workforce is located in Perth, while only 0.4% are in Gascoyne. At the same time, the Pilbara accounted for more than 60% of WA's exports in 2016; Perth only accounted for 15%.

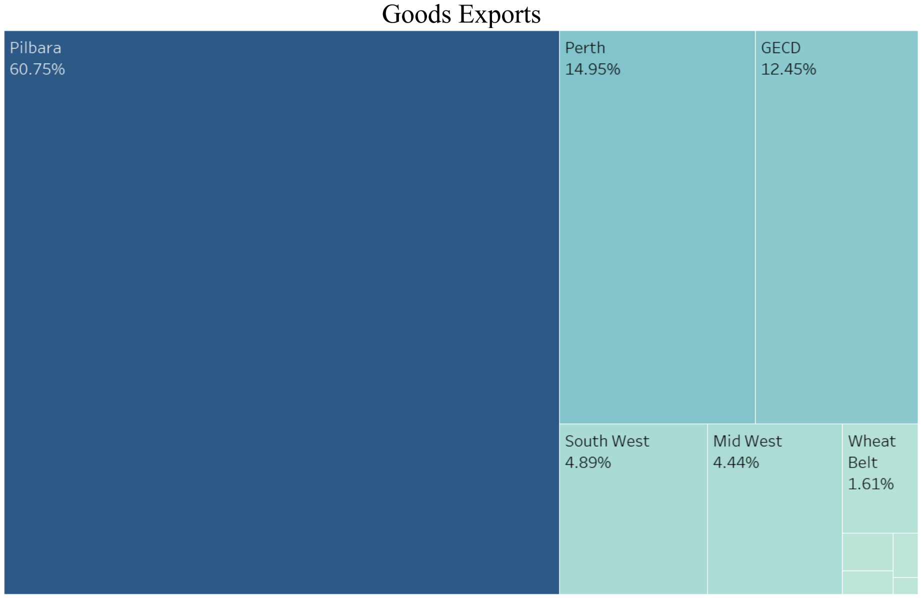
In some respects, the broad employment profiles of various regions are comparable. As shown in **Figure 25**, at least 60% of each region's employment in 2019 was accounted for by services (which here includes IT, scientific, management, administrative, educational, health care, arts, entertainment, and miscellaneous services), construction, and retail. However, each region's employment concentration in particular industries varies more substantially. **Figure 26** shows the industry in which each region's employment is most intensive (overrepresented). Importantly, the construction category includes construction for mining.

Figure 24: Employment and Exports by Region

Employment

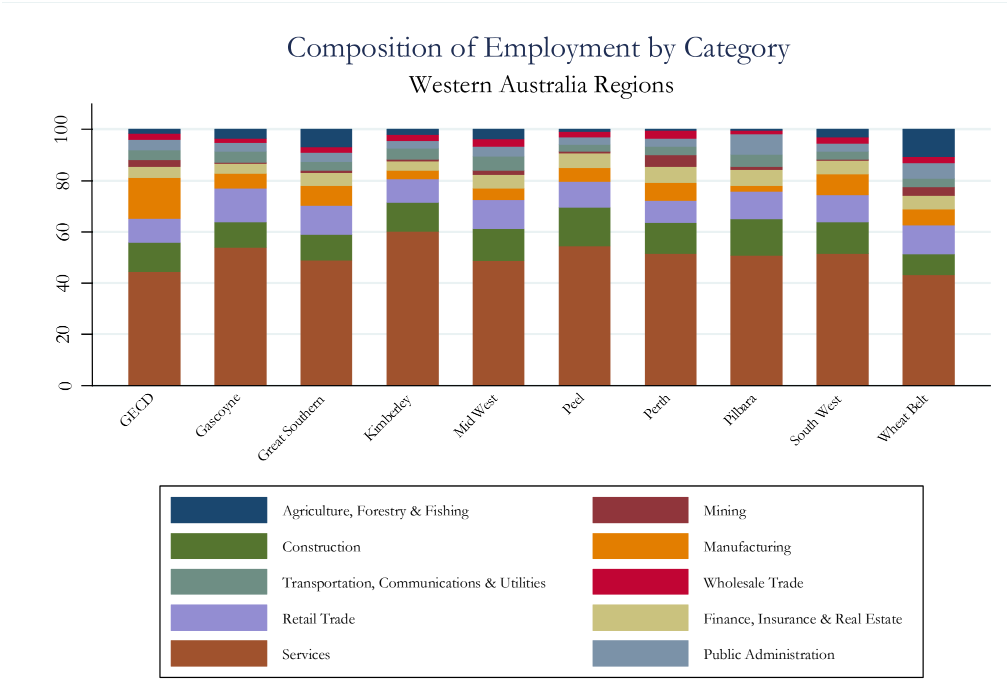


Goods Exports



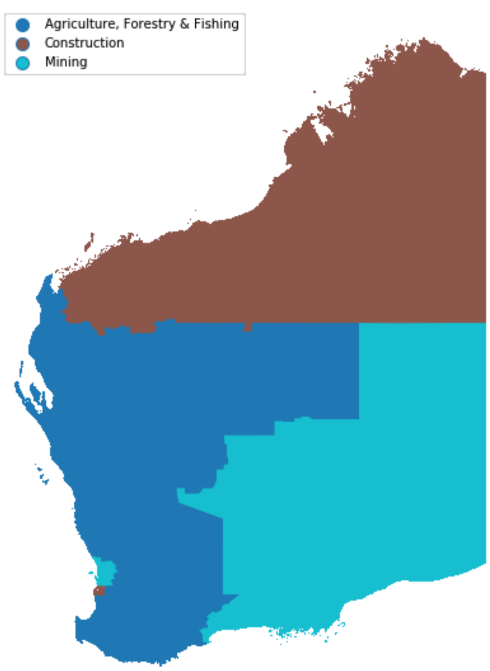
Source: Own construction based on D&B, ABS, and COMTRADE

Figure 25: Composition of Employment by Region



Source: Own construction based on D&B

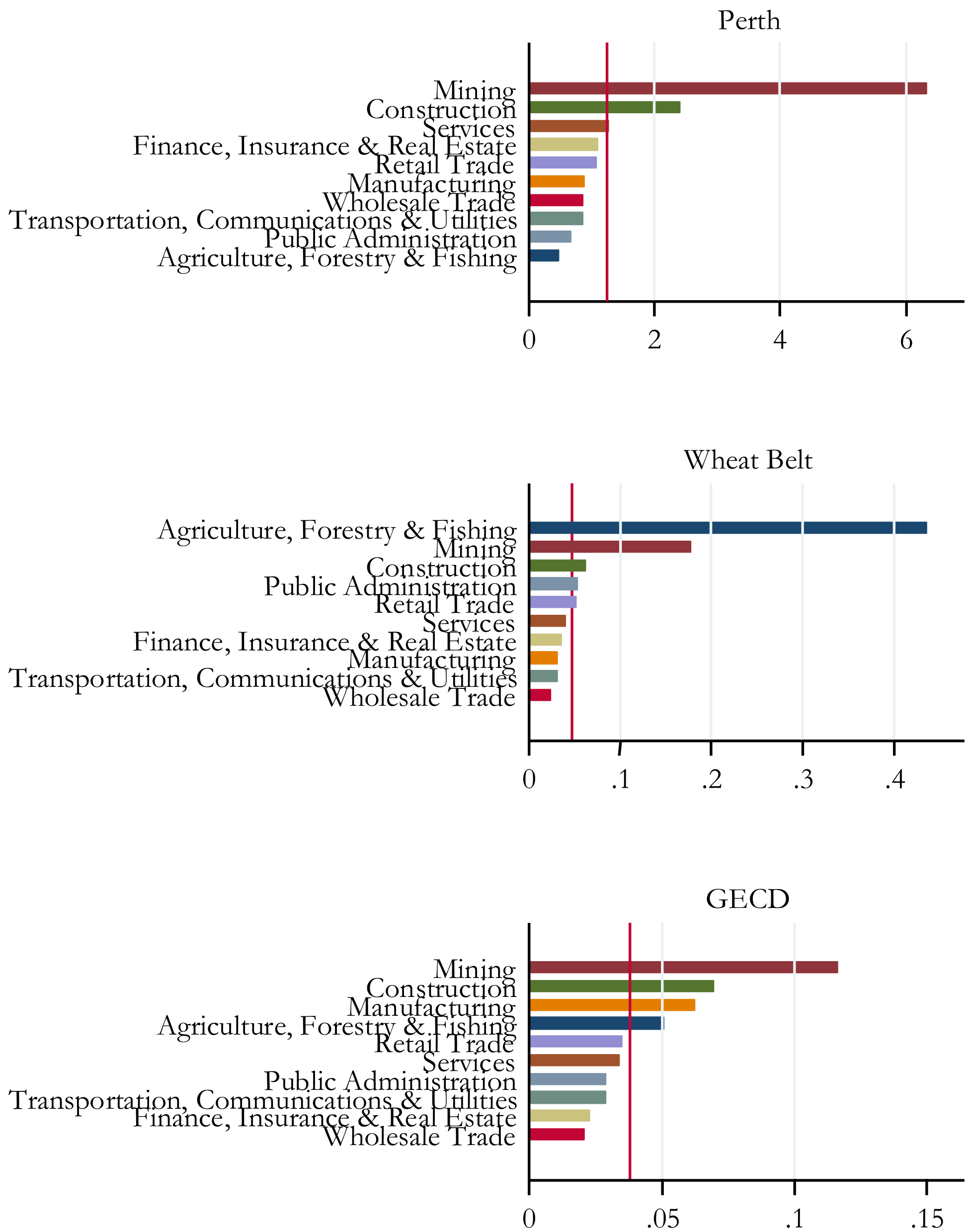
Figure 26: Highest Relative Intensity Sector (Relative to the Peer Group), WA Regions

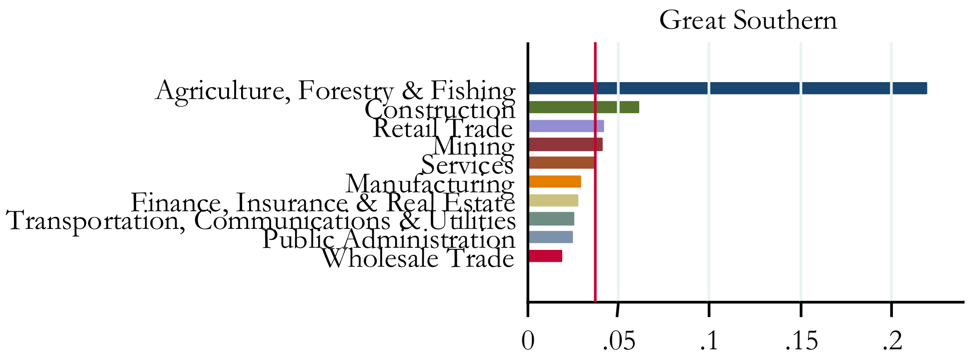


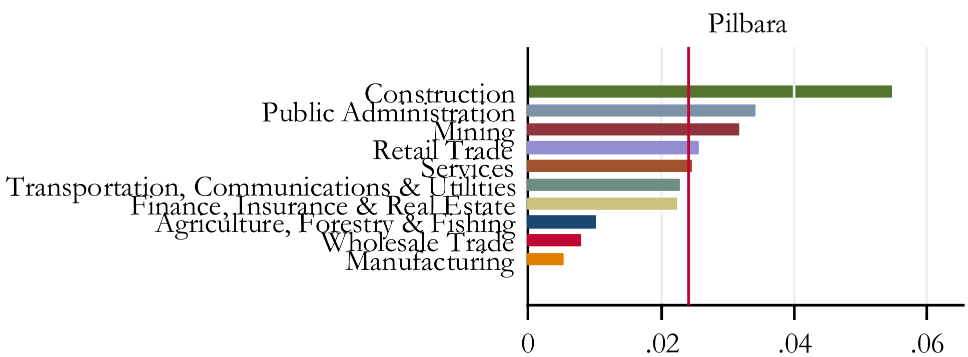
Source: Own construction based on ABS and COMTRADE

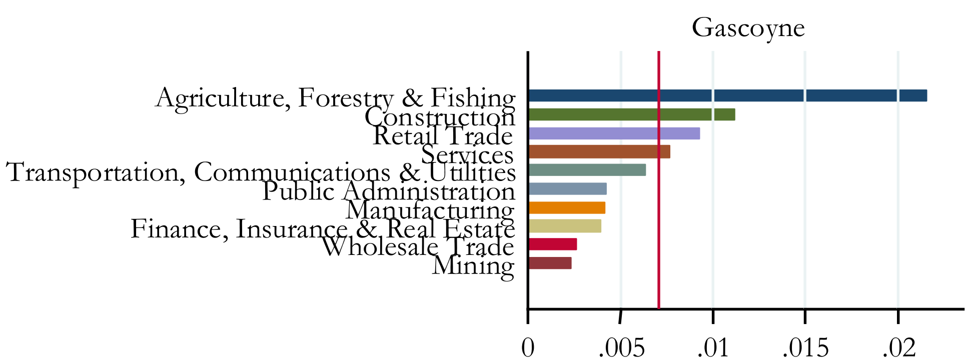
A more detailed breakdown of job intensity by region is shown in **Figure 27**, which shows the number of jobs in each region-industry pair as a share total employment in the industry across the peer group. As can be seen, most regions are specialized in some combination of agriculture, construction, mining, and services. For example, the Great Southern has over 0.2% of agriculture, forestry and fishing jobs in the peer group (in comparison to less than 0.05% of jobs overall).

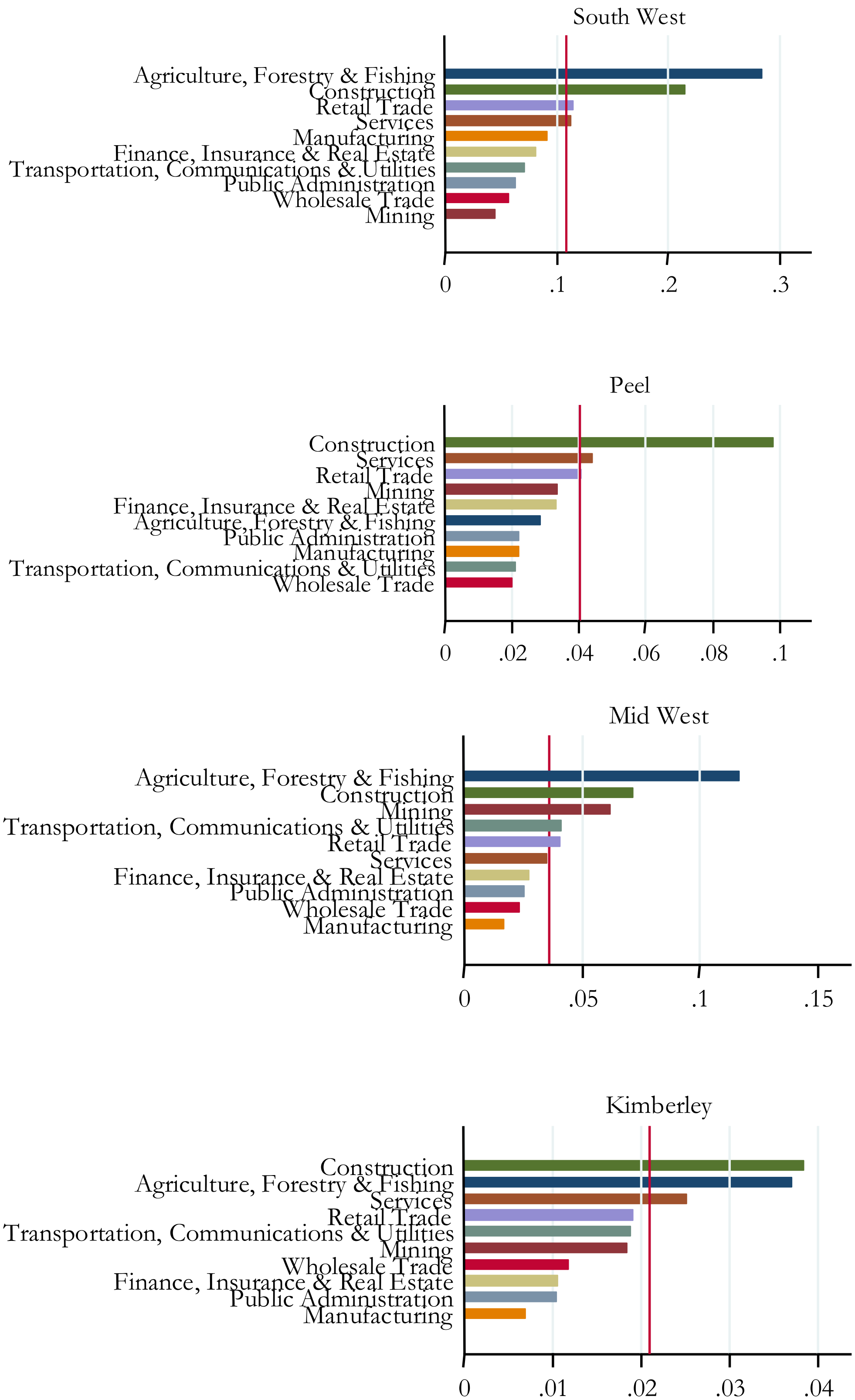
Figure 27: Share of Employment Among Global Peers by Sector (Region Share of Total Employment as Vertical Line)




Great Southern
Agriculture, Forestry & Fishing
Construction
Retail Trade
Mining
Services
Manufacturing
Finance, Insurance & Real Estate
Transportation, Communications & Utilities
Public Administration
Wholesale Trade
0
.05
.1
.15
.2


Pilbara
Construction
Public Administration
Mining
Retail Trade
Services
Transportation, Communications & Utilities
Finance, Insurance & Real Estate
Agriculture, Forestry & Fishing
Wholesale Trade
Manufacturing
0
.02
.04
.06

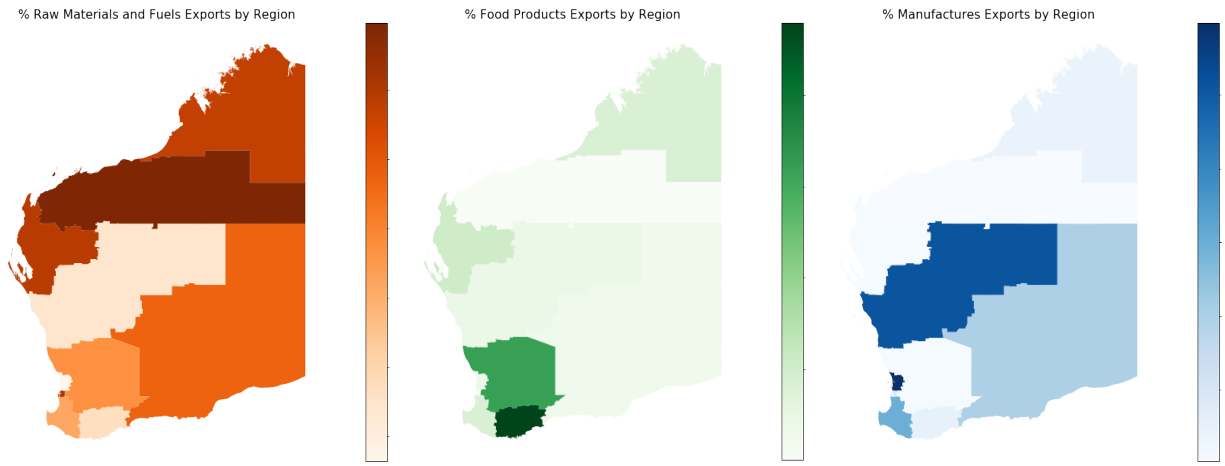

Gascoyne
Agriculture, Forestry & Fishing
Construction
Retail Trade
Services
Transportation, Communications & Utilities
Public Administration
Manufacturing
Finance, Insurance & Real Estate
Wholesale Trade
Mining
0
.005
.01
.015
.02



Source: Own construction based on ABS and COMTRADE

In terms of exports, the main export industry in each region, as projected by the random forest machine learning algorithm, varies sharply (**Figure 28**). While the Pilbara, Goldfields-Esperance, Kimberley, and Gascoyne produce exports concentrated in minerals, the southwest corner of WA is specialized in agriculture. Notably, Perth and the Mid-West participate more strongly in manufacturing exports.

Figure 28: Exports by Sector Heat Maps, WA Regions
(Relative Heat Scale: Lightest Color is Minimum Value, Darkest Color is Maximum Value)



Source: Own construction based on ABS and COMTRADE

b) Economic Complexity of Western Australia

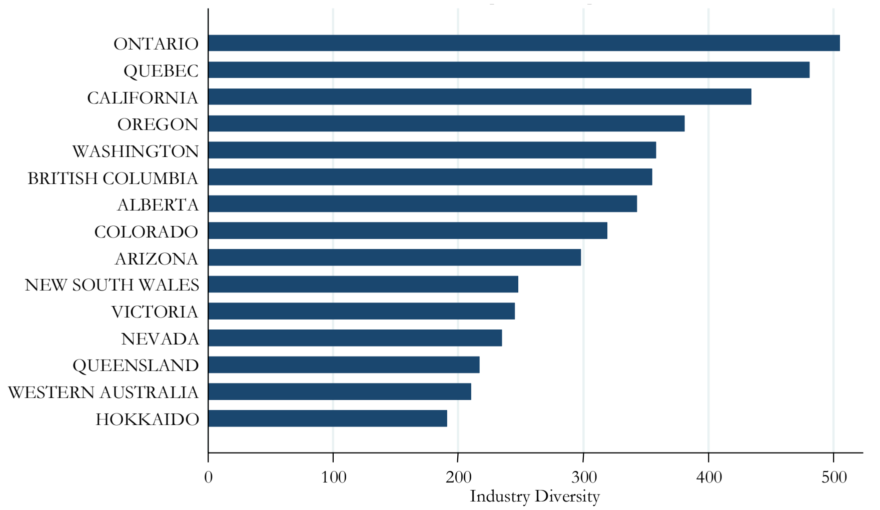
Having established a set of stylized descriptive facts about WA's economy, we can now turn to its economic complexity. WA's diversification, position in the Employment and Export Spaces, economic complexity, and outlook for further diversification are discussed here before moving to the identification of diversification opportunities.

WA specializes in a small number of industries and has experienced little diversification into new industries.

In terms of employment, WA is one of the least diverse states of the peer group. Although it is true that other Australian states in the peer group are located in the lower part of the spectrum, WA's employment is less diverse than each of them and more diverse than only Hokkaido. WA's employment structure is intensive in approximately 200 industries, less than half the diversity of places like Ontario, Quebec and California, as shown in **Figure 29**.[12] This also translates into an Employment Space that is sparsely but fairly evenly populated, which is shown in **Figure 30**.

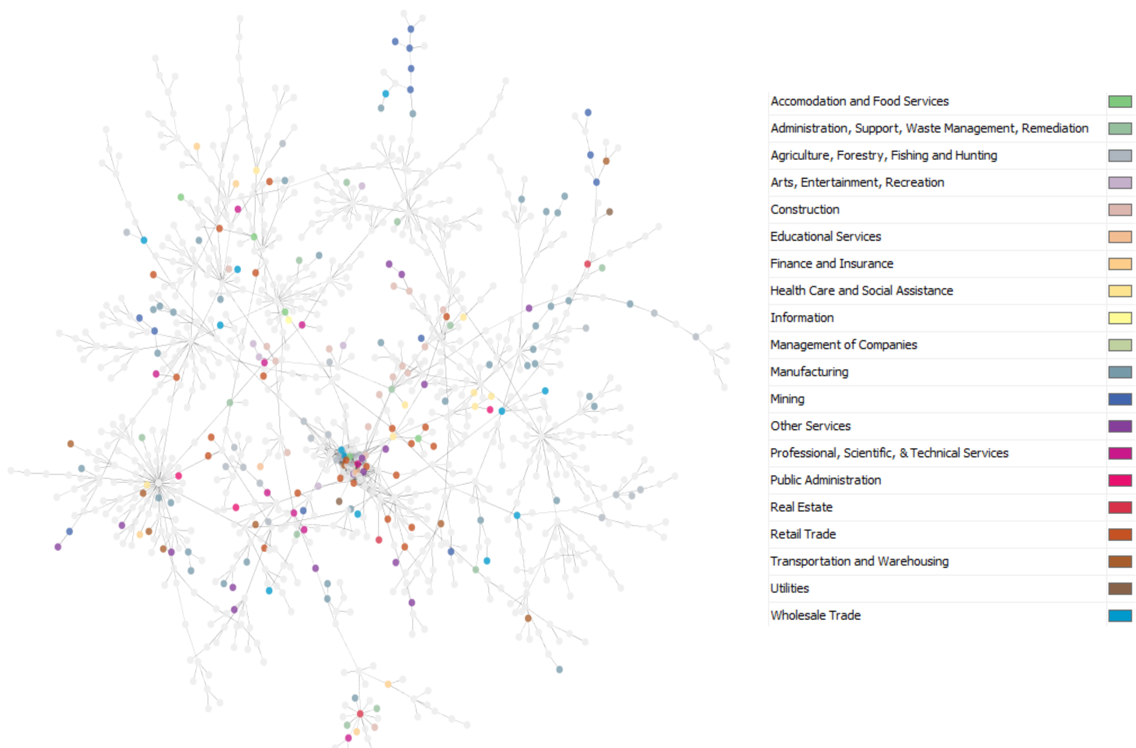
[12] Note that industry diversity is correlated with population but that rankings diverge significantly.

Figure 29: Employment Diversity, WA and Peer States



Source: Own construction based on D&B

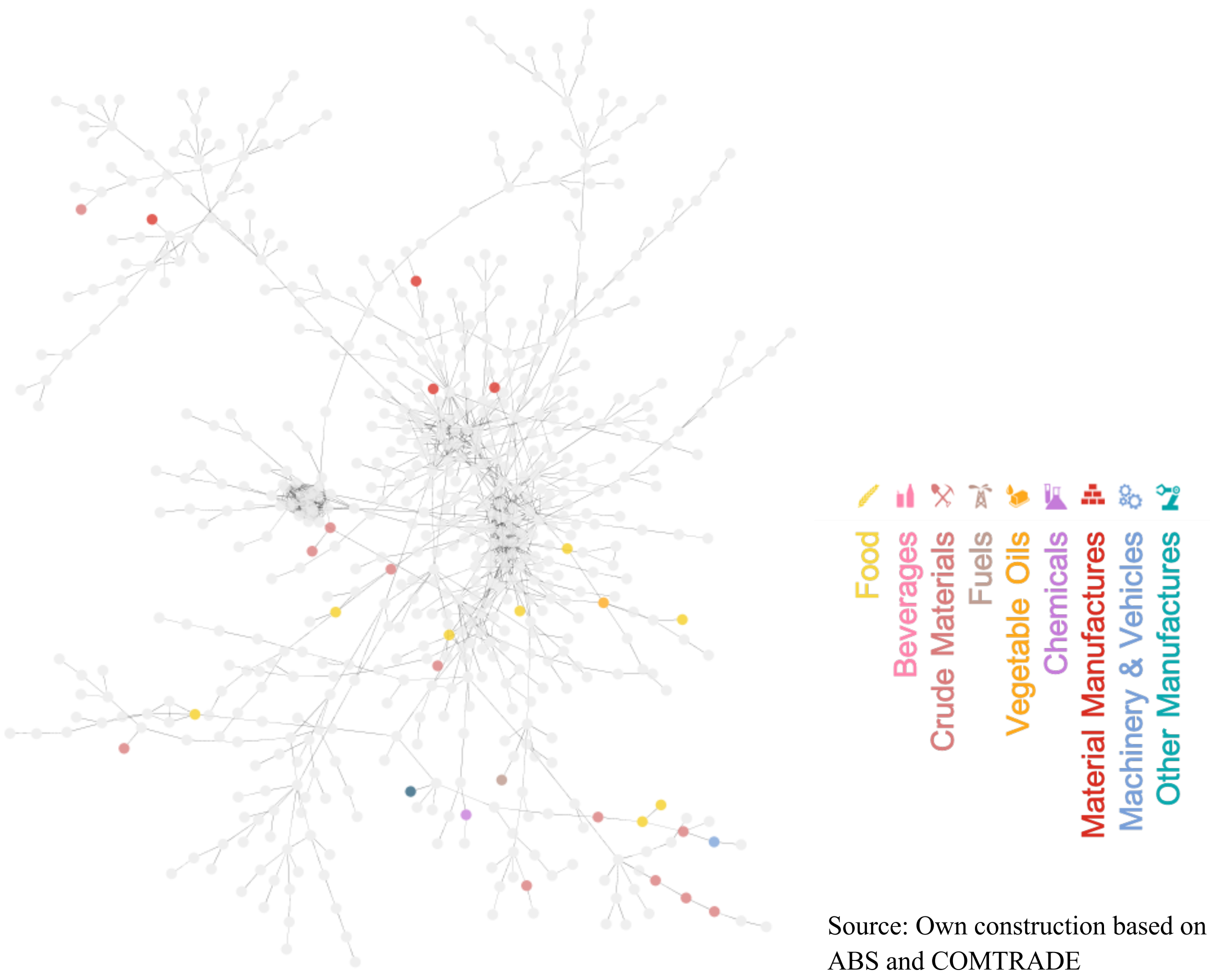
Figure 30: WA's Employment Space



Source: Own construction based on D&B

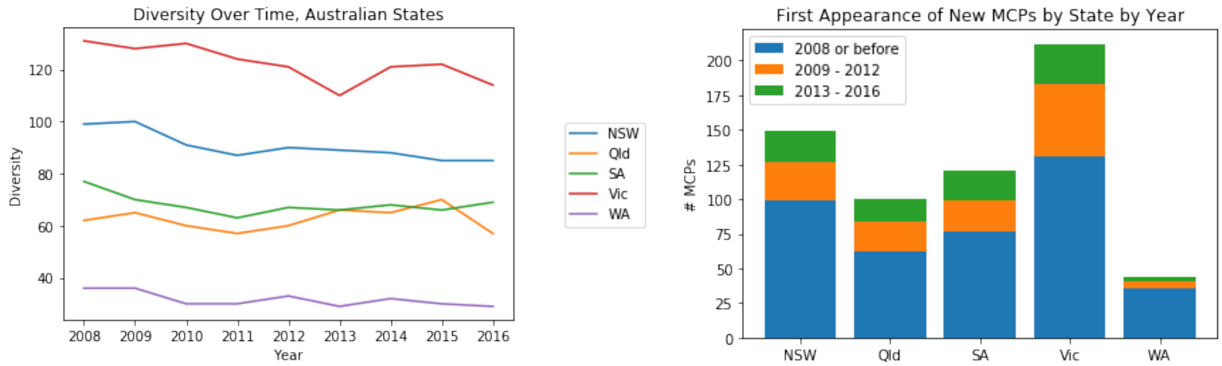
WA's export basket has likewise displayed consistently low diversity. During the 2008-2016 period WA's export diversity (measured in relation to countries) averaged 32 products, the lowest of any large Australian state and comparable to that of Saudi Arabia. This translates into a sparsely populated Export Space, which is shown in **Figure 31**. WA's low diversity reflects the cumulative result of difficulty in adding new products to its export basket over time. As shown in **Figure 32**, WA's diversity over 2008-16 was on average 27% of that of Australia's most diverse state, Victoria. Over this period, WA added only three new products (as measured by RCA>1), the lowest total of any state. By contrast, Victoria added 76 products over the same time period. It is noteworthy that WA did not diversify into products that are exported intensively by other Australian states.

Figure 31: WA's Export Space



Source: Own construction based on ABS and COMTRADE

Figure 32: Australian States' Exports Diversity over Time and New Export Appearances



Source: Own construction based on ABS and COMTRADE
Note that the graph on the left captures both product appearances and disappearances, while that on the right counts only appearances.

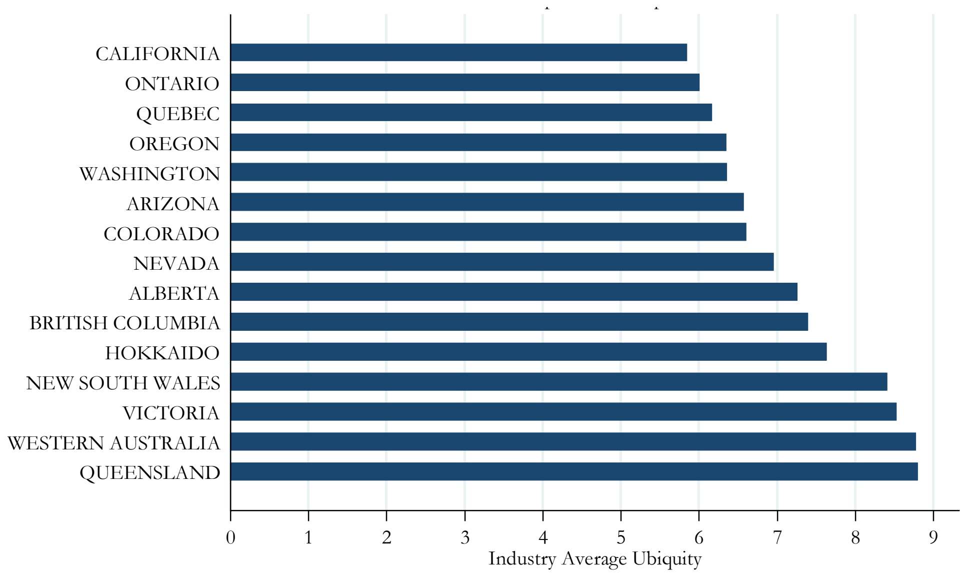
WA's low diversification into new industries is also reflected in the composition of its exports according to volume. As shown in **Figure 33**, new export RCAs added since 2008 account for approximately 1% of WA's total goods export volumes.

Figure 33: WA's 2016 Goods Exports by Share, Old (Light Green) vs. New (Dark Green)

Source: Own construction based on ABS and COMTRADE

Notably, the average ubiquity of WA's industries differs between the employment and export analyses. Under the employment approach, WA's industries are among the most ubiquitous of the peer group, only (marginally) above those of Queensland (**Figure 34**). On average, an industry present in WA is also present in 9 out of 15 peer states.

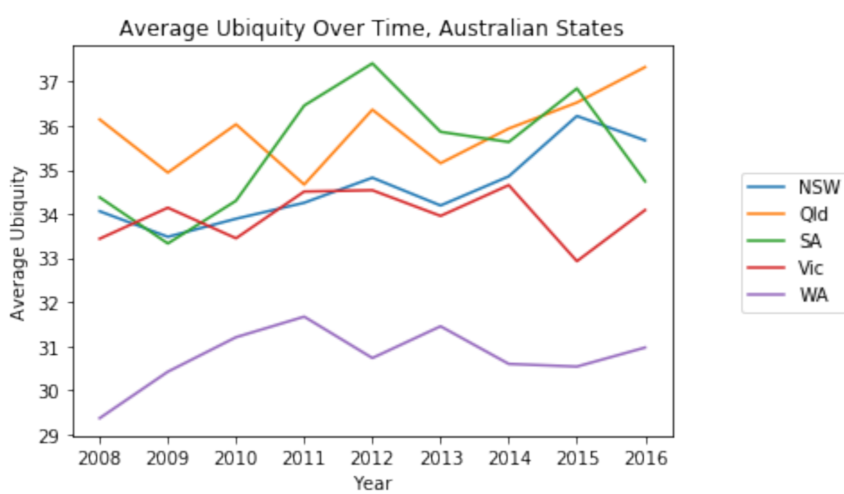
Figure 34: Employment Ubiquity by State



Source: Own construction based on D&B

In contrast, WA's exports have persistently been the least ubiquitous in the country (**Figure 35**), albeit with a slight increase due to comparative advantages in new minerals.

Figure 35: Export Ubiquity by State



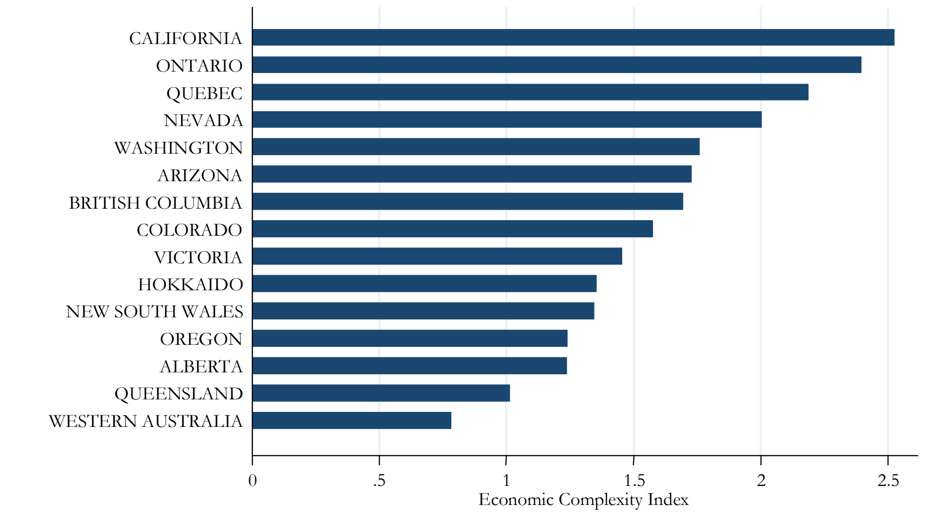
Source: Own construction based on ABS and COMTRADE

The difference between WA's export ubiquity and employment ubiquity is interesting to consider. It may be that the same type of economic production in WA requires relatively ubiquitous types of jobs but creates relatively niche exports. One might imagine such logic could apply to WA's mining industry. That is, a relatively uniform set of jobs may be required to extract a wide variety of minerals, which would lead to high employment ubiquity but lower export ubiquity.

WA has a low level of economic complexity, which is explained both by its concentration in low-complexity industries and its low-complexity activity across a broad variety of industries.

WA shows the lowest level of economic complexity of any peer state based on the employment approach, as shown in **Figure 36**. This reflects that the state's employment sources have both low diversity and relatively high average ubiquity.

Figure 36: ECI Based on Employment, WA and Peer States



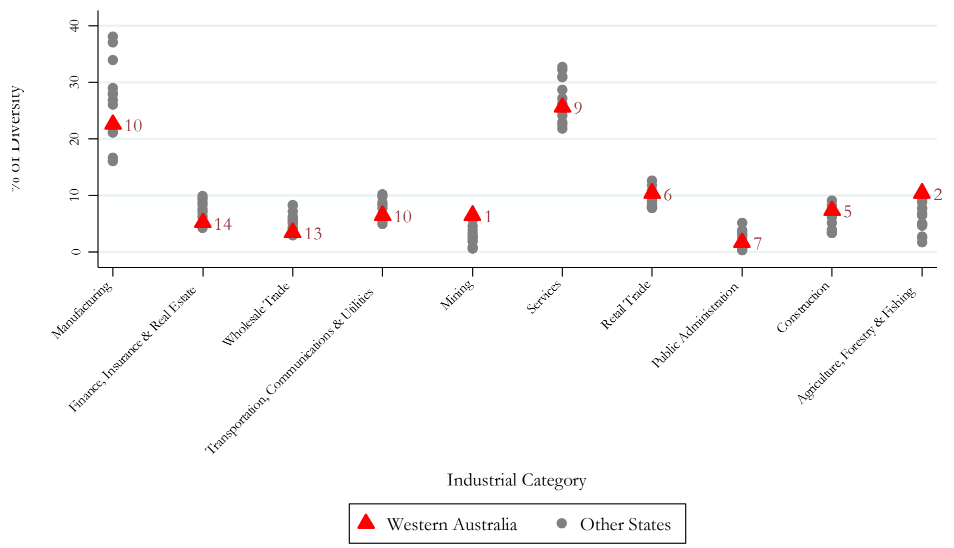
Source: Own construction based on D&B

A closer look into the composition of WA's employment shows that much of the state's already-low diversity comes from low-complexity sectors such as mining. **Figure 37** shows what percentage of WA's employment-based diversity is obtained from each sector, along with how that ranks across the peer states. WA gets a higher share of its employment diversity from mining than any other state in the peer group, the second highest share among the group from agriculture, and fifth highest from construction. All of the sectors that represent a relatively high share of WA's diversity are relatively low complexity. Conversely, WA gets little of its employment diversity from manufacturing (where it ranks 10th) or from finance (where it ranks 14th), which are high-complexity sectors.

Additionally, WA's employment sources tend to be low complexity regardless of sector. That is, even for sectors that are high complexity on average, WA tends to have intensive presence in low-PCI industries. This is shown in **Figure 38**. WA ranks 14th or 15th for seven out of ten sectors, including manufacturing, finance, and services. An important exception is agriculture, in which

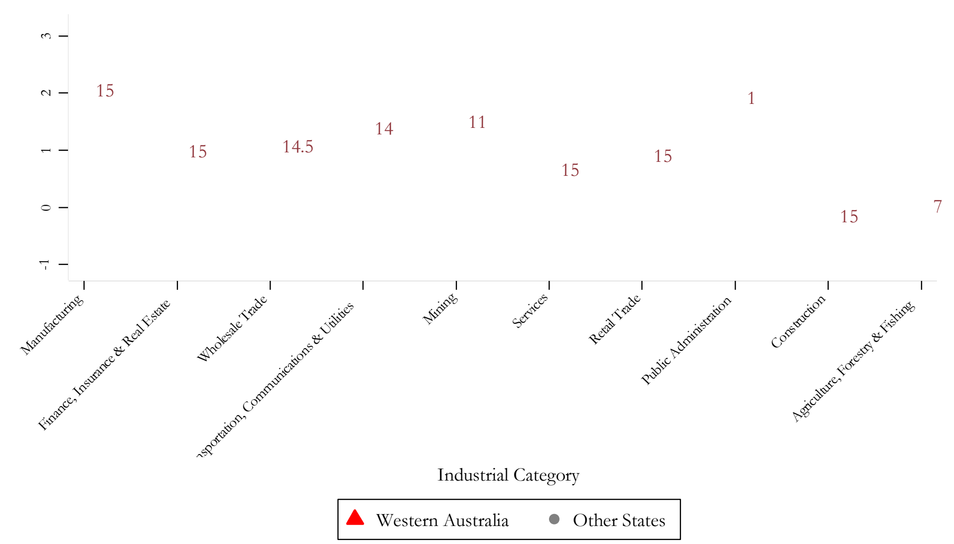
WA ranks 7th. WA also ranks as the most complex in public administration, which may reflect a concentration of public employment in activities typically associated with greater complexity, such as the administration of utilities. It may have to do as well with the remoteness of the state and necessary public administration roles that are required to deliver public services to remote places.

Figure 37: Percent of Employment Diversity from Each Sector (Rank by Sector in Red)



Note: The number in red denotes WA's ranking within the peer group (15 states, including WA)
Source: Own construction based on D&B

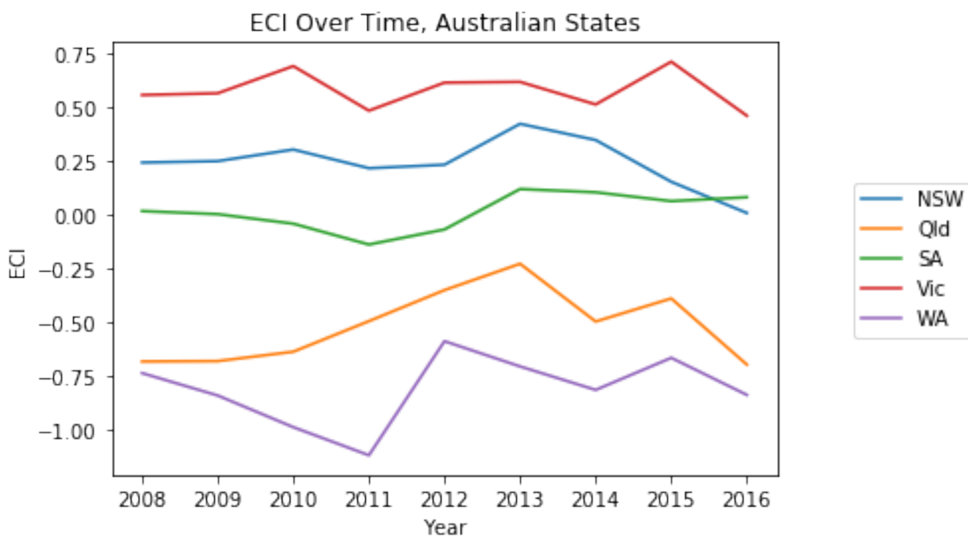
Figure 38: Average PCI of Employment in Each Sector (Rank by Sector in Red)



Note: The number in red denotes WA's ranking within the peer group (15 states, including WA)
Source: Own construction based on D&B

The export analysis yields similar conclusions. As shown in **Figure 39**, WA has the lowest complexity of any large Australian state, only comparable with Queensland and at a considerable distance behind Victoria, New South Wales, and South Australia. Although ECI has jumped around somewhat,[13] WA has had low export complexity consistently over the past decade.

Figure 39: Evolution of ECI Based on Exports over Time, Australian States



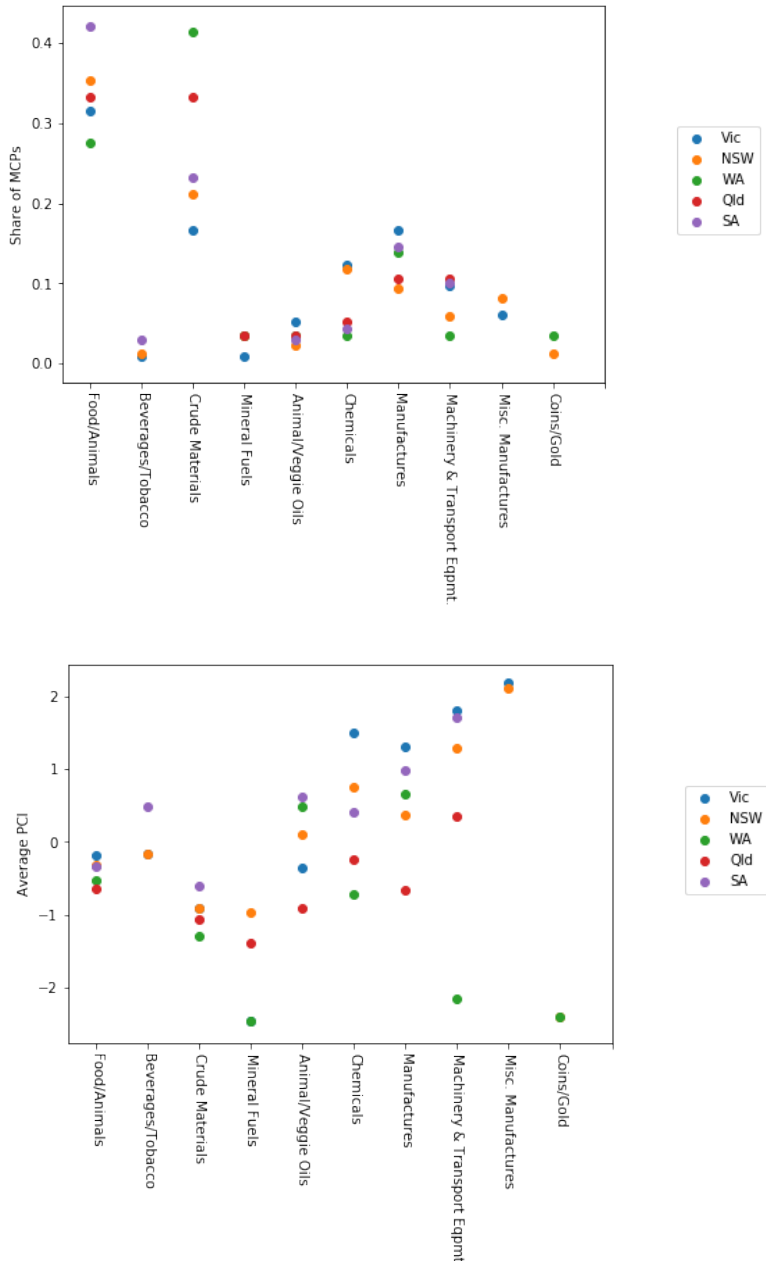
Source: Own construction based on ABS and COMTRADE

As with employment, WA's low export complexity is the result of much of its diversity coming from low-complexity sectors as well its low product complexity across a most sectors. **Figure 40** shows these patterns. A large share of WA's diversity comes from crude materials, while comparatively low proportions come from sectors such as manufactures and machinery. The PCI of WA's export RCAs are noticeably low in crude materials, mineral fuels, chemicals, and machinery.

It is useful to also observe these patterns in WA's overall export and employment volumes. In 2016, only 7% of WA's exports were in products with positive (above-average) PCI, as shown in **Figure 41**. Meanwhile, less than 2% of WA's overall employment in 2019 was in industries that were in the top 30% of complexity, as shown in **Figure 42**.

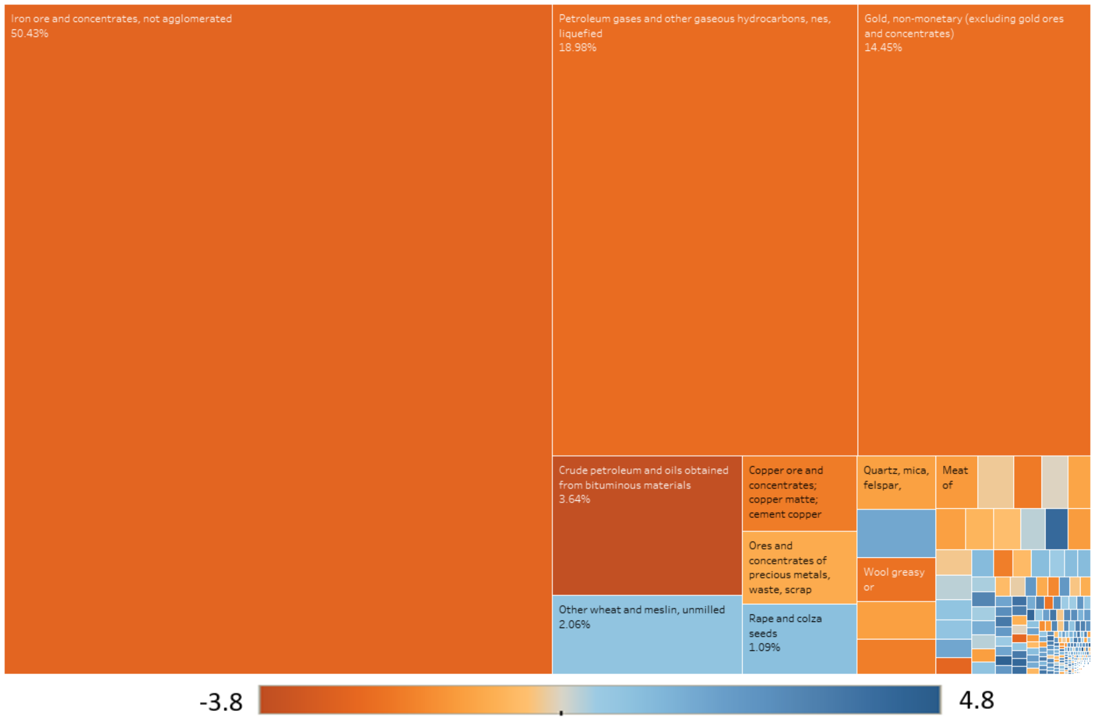
[13] Given the state's overall low level of diversity, adding or losing few products may have significant effects on ECI.

Figure 40: Proportion of Export Diversity and Average PCI by Sector



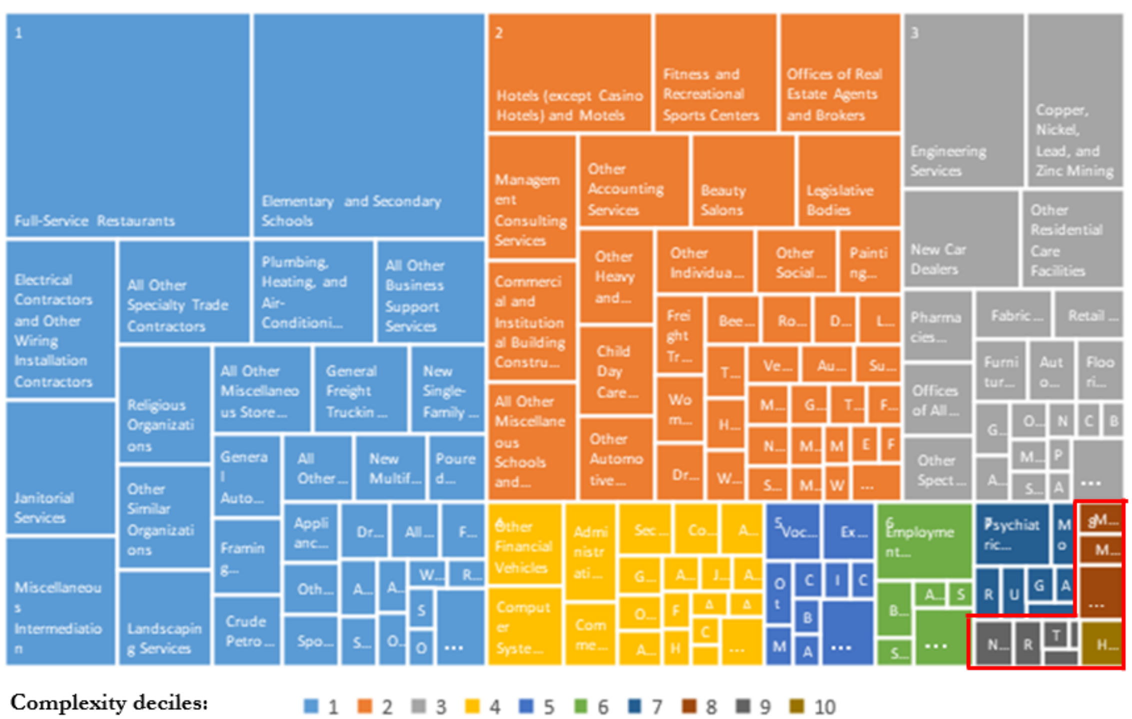
Source: Own construction based on ABS and COMTRADE

Figure 41: WA Exports Colored by PCI, 2016



Source: Own construction based on ABS and COMTRADE

Figure 42: WA Employment Colored by PCI Decile, 2019

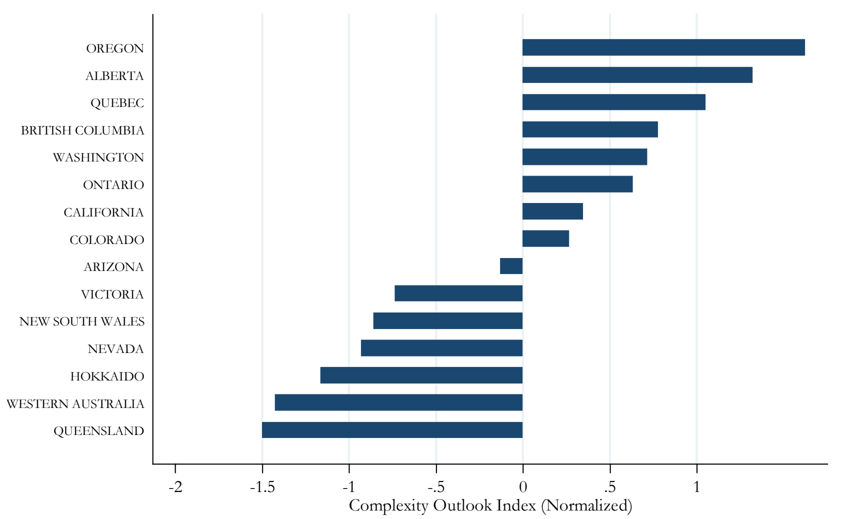


Source: Own construction based on D&B

WA not only has low complexity, but also faces difficulties increasing its complexity because it has a low complexity outlook index (COI).

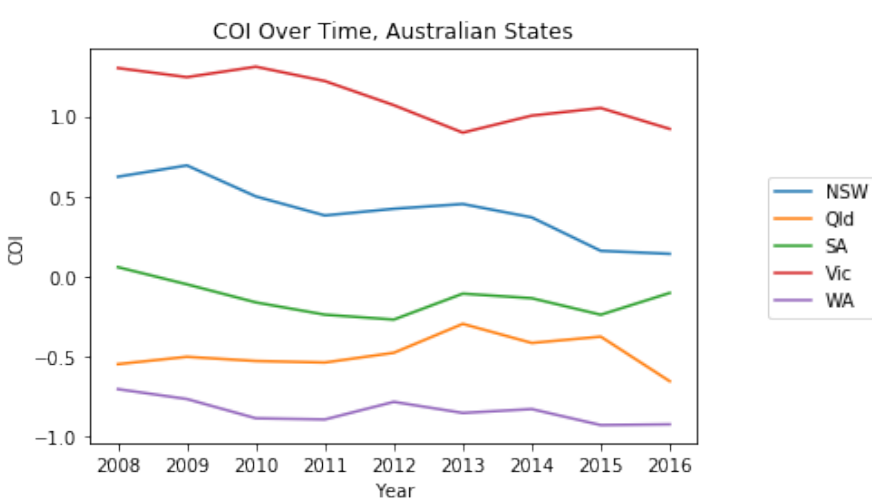
WA's productive capabilities do not put it in a position that is well "connected" to more complex activities. Regardless of whether we measure WA's capacities based on employment or exports, the state ranks poorly in the COI metric. When calculated based on employment, shown in **Figure 43**, WA ranks second to last within the peer group, only ahead of Queensland. When using exports, shown in **Figure 44**, WA has the lowest COI of any large Australian state. As with ECI, this low COI has been consistent throughout the past decade. As a result, we can conclude that *status quo* strategy is not leading to significant diversification.

Figure 43: COI based on Employment, WA and Peer States



Source: Own construction based on D&B

Figure 44: Evolution of COI Based on Exports over Time, Australian States

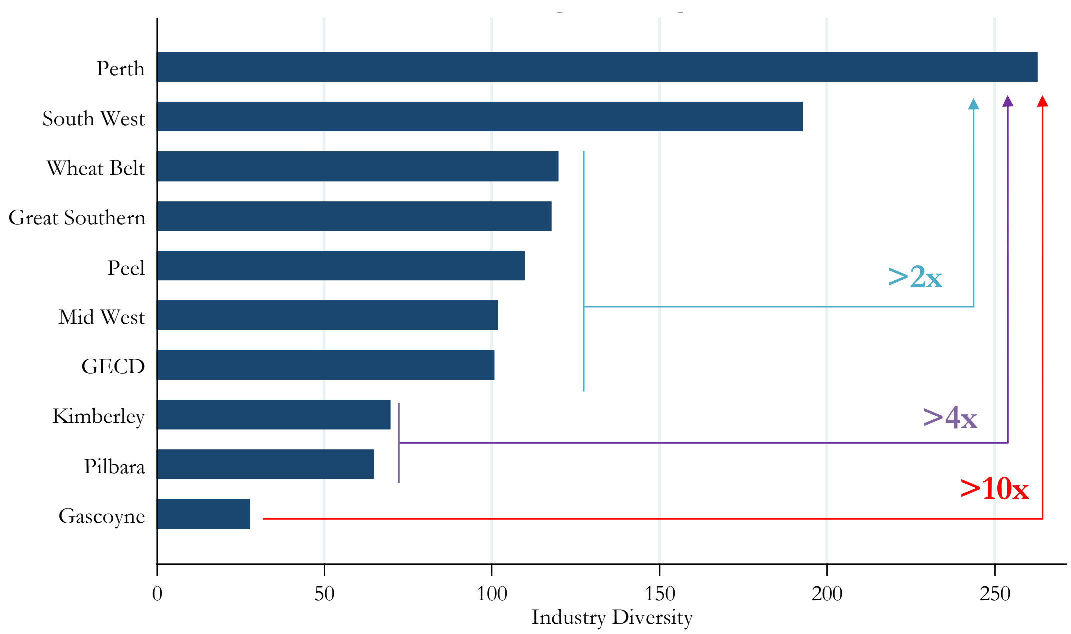


Source: Own construction based on ABS and COMTRADE

WA regions show significant differences in terms of diversity and average ubiquity.

Both in terms of employment and exports, WA regions show significant differences in diversity and average ubiquity. Perth has an employment diversity of more than 250 industries, as shown in **Figure 45**. Aside from the South West, which has a diversity of nearly 200, all other regions have half the level of Perth or less. The northern regions (Kimberley, Pilbara, and Gascoyne) are the least diverse. Employment Spaces for region are provided in Annex 2 and show the substantial difference in employment structures between Perth and the Southwest and between the Southwest and other regions.

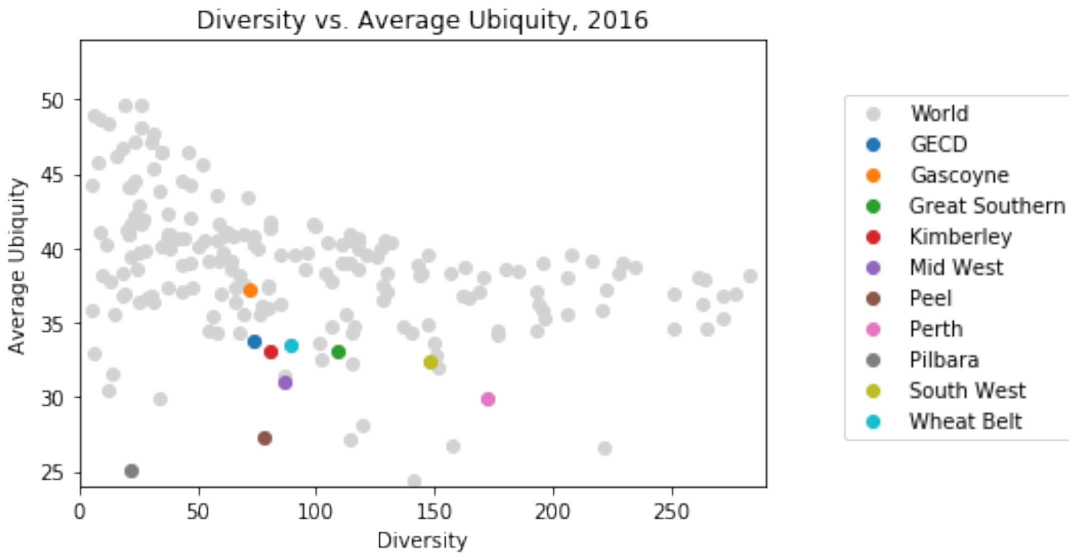
Figure 45: Diversity based on Employment, WA Regions



Source: Own construction based on D&B

The picture is broadly similar if, instead of employment, we look at diversity and average ubiquity of exports. **Figure 46** shows each of these variables on the two axes for each region of WA, with countries shown as gray markers. Perth and the South West again have the highest diversity – about 175 and 150 industries, respectively – whereas the other regions, with the exception of the Great Southern, have diversity below100 industries. All of the regions tend to have a low average ubiquity of exports given their diversity, and this is especially true for Pilbara and Peel. This tendency matches the interesting position of state-level exports overall as low diversity-low average ubiquity. The graph shows here the extent to which Pilbara's mining exports pull the state into this position and the extent to which Perth's more diversified economy pulls the state toward the more desirable position in the graph.

Figure 46: Diversity and Average Ubiquity Based on Exports, WA Regions

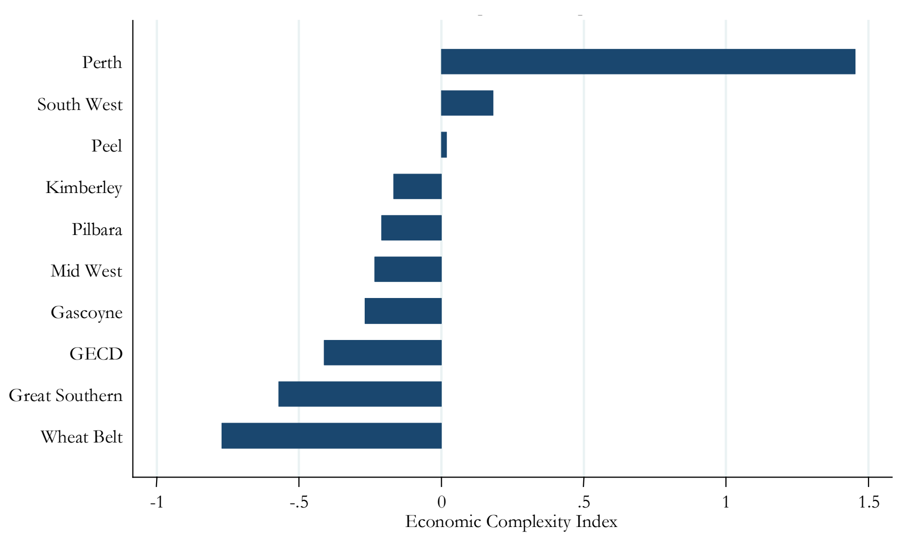


Source: Own construction based on ABS and COMTRADE

Perth is by far the most complex region of WA and is best-connected to new diversification opportunities.

The employment analysis shows that Perth's complexity is far larger than any other region (**Figure 47**), while the South West and Peel also have an above average complexity. On the other hand, the Wheat Belt, Great Southern, and Goldfields-Esperance have much lower (and below average) complexity.

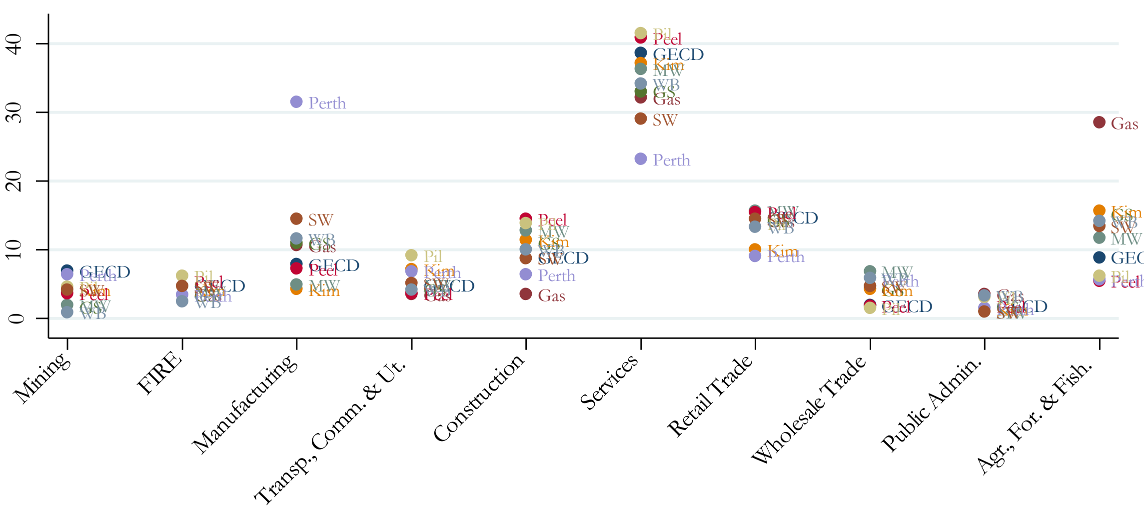
Figure 47: ECI Based on Employment, WA Regions



Source: Own construction based on D&B

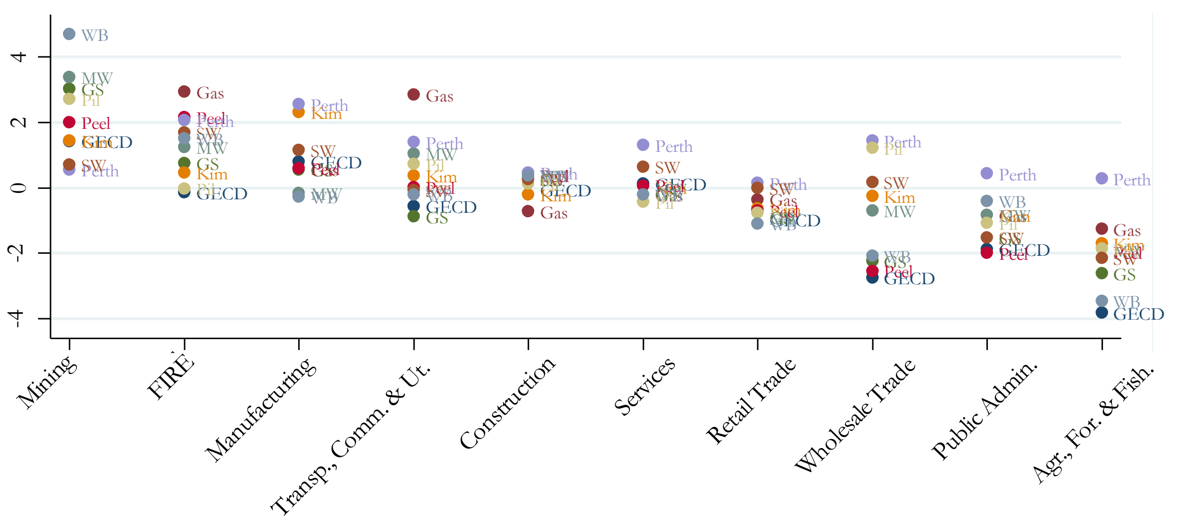
Perth's high employment-based complexity is explained both by its diversity coming from high-complexity sectors and its high complexity across multiple sectors. **Figure 48** shows that Perth obtains a large portion of its diversity from manufacturing, which is a high-complexity sector. **Figure 49** shows that Perth's industries also have relatively high PCIs across several sectors, including manufacturing, services, agriculture, wholesale trade, and public administration.

Figure 48: Percent of Employment Diversity Obtained from Each Sector



Source: Own construction based on D&B

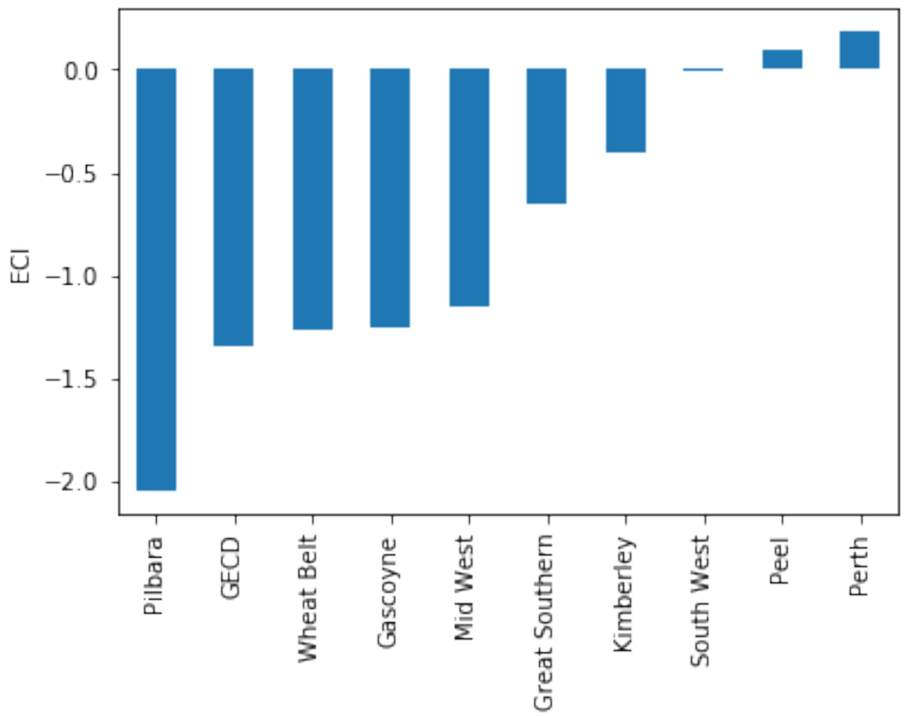
Figure 49: Average Complexity of Employment in Each Sector



Source: Own construction based on D&B

In terms of exports, Perth remains the most complex region, although the gap between it and the next several regions (again Peel and South West) is smaller, as shown in **Figure 50**. As shown in **Figure 51,** Perth registers as the most complex region both because it is highly concentrated in complex sectors (manufacturing and machinery & transport equipment) and because it shows high levels of product complexity across various sectors (beverages, crude material, manufactures).

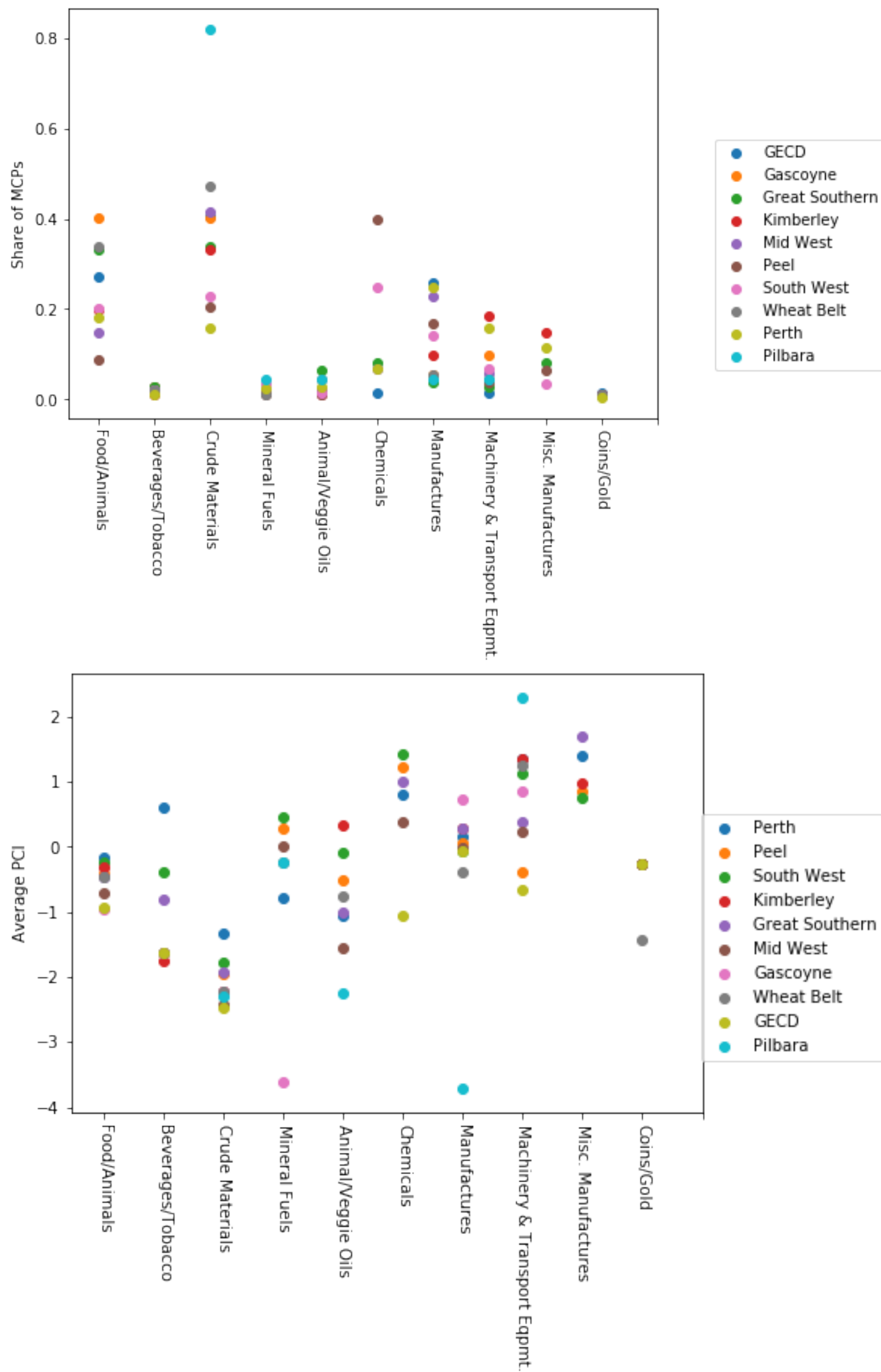
Figure 50: ECI Based on Exports, WA Regions



Source: Own construction based on ABS and COMTRADE

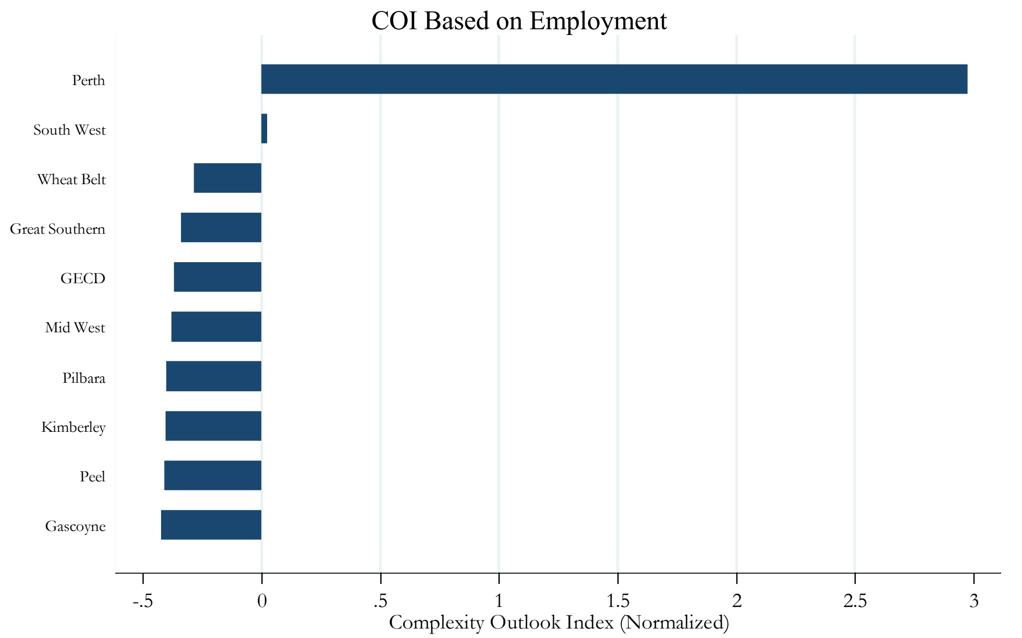
At the same time, Perth is in a much more advantageous position to improve its complexity than the rest of the state, as shown in **Figure 52**. The employment analysis for Perth yields a very high COI, while nearly all other regions have a low COI. Using the exports approach, Perth once again has the highest COI but the gap versus other regions is smaller. The South West also scores quite well in export-derived COI, while the Great Southern has a COI above the global average and the Mid West has a COI just under the global average. More remote regions have much lower COIs, especially Pilbara, Gascoyne, and Goldfields-Esperance.

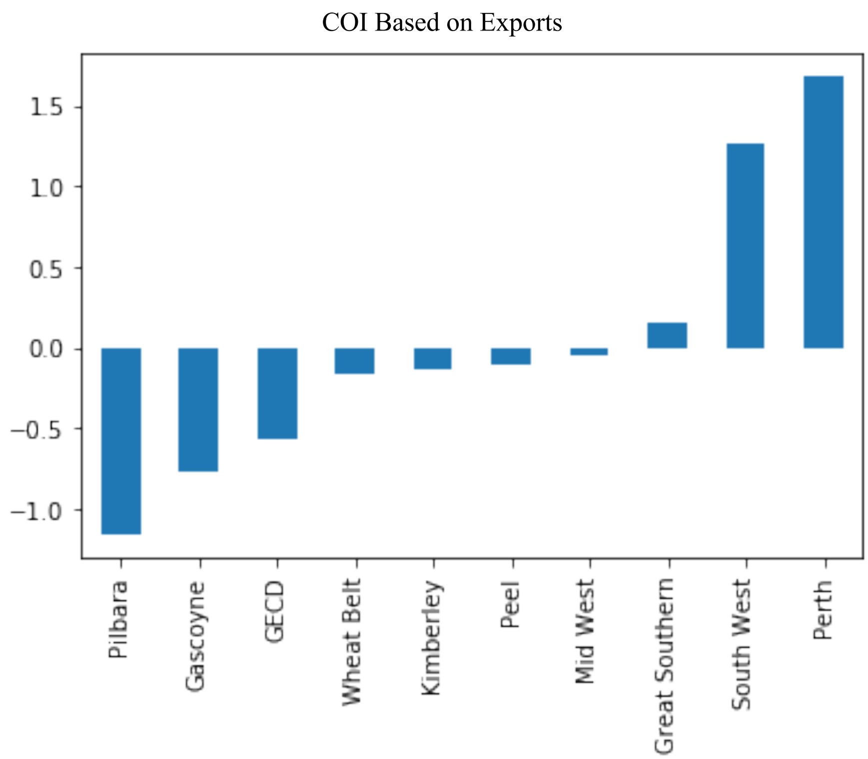
Figure 51: Proportion of Export Diversity and Average PCI by Sector, WA Regions



Source: Own construction based on ABS and COMTRADE

Figure 52: COI Based on Employment (top) and Exports (bottom), WA Regions



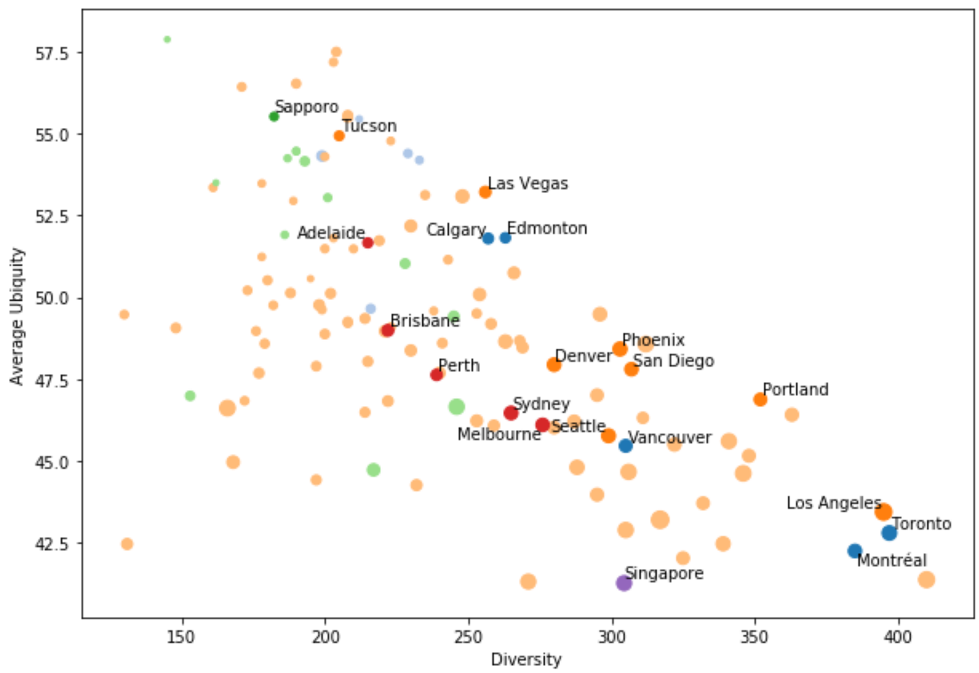


Source: Own construction based on D&B, ABS and COMTRADE

Compared to global cities, Perth is reasonably complex overall. It has somewhat low complexity for its size, but its complexity outlook index is more encouraging.

While the above analysis is useful for comparing Perth's economic structure with other regions of the state, it does not yield insights of Perth in comparison to other global cities. However, this perspective can be gained by through extending the employment analysis based on D&B data to other cities in the world. As compared to a basket of American, Canadian, Japanese, and Australian cities with metro area populations above 500,000, Perth has levels of employment diversity and average ubiquity that are approximately in the middle of the pack. **Figure 53** shows this pattern, with a number of cities from peer states (plus Singapore) bolded and labeled.

Figure 53: Employment Diversity vs. Average Ubiquity for Global Cities (Bubble Size by Population, Color by Country)

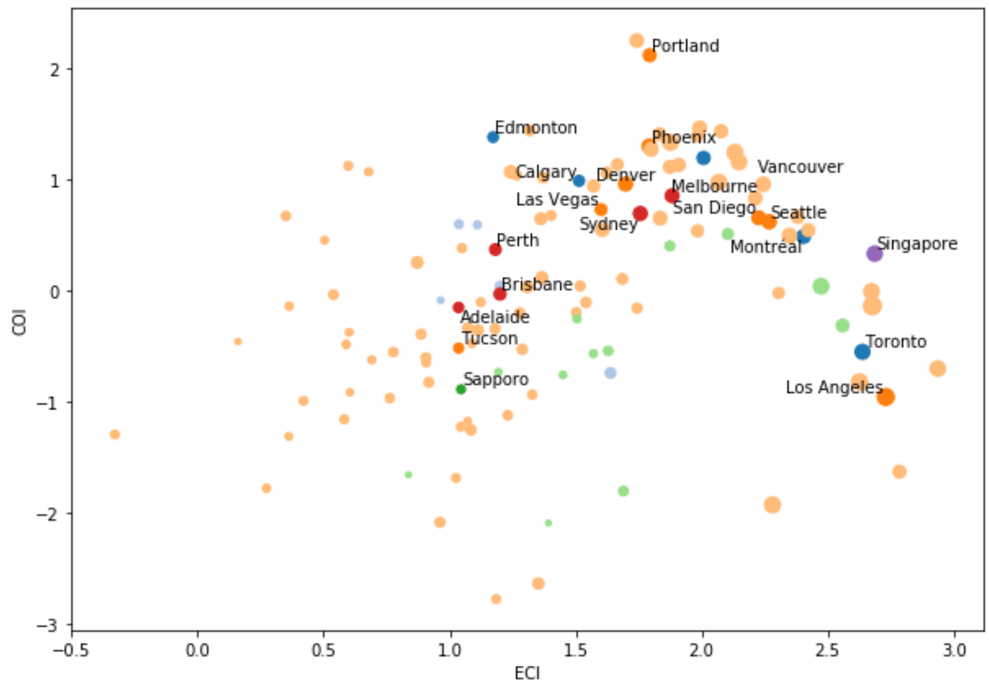


Source: Own construction based on D&B

Unsurprisingly, Perth has greater employment diversity than a number of relatively small cities, but lower levels as compared to major world cities such as Singapore, Los Angeles, and Toronto. Compared to other large Australian cities, Perth has somewhat lower diversity than Sydney or Melbourne but higher diversity than Adelaide or Brisbane. Similar patterns apply for average ubiquity. As with WA as a whole and its regions, Australian cities also tend to have low average ubiquity for their diversity. Several medium-size North American cities, including in western U.S. states have greater employment diversity than similarly sized Australian cities.

Perth's employment-based ECI and COI are also relevant to compare versus other cities. As shown in **Figure 54**, Perth skews towards the lower-middle part of the ECI distribution among peer cities. Importantly, its ECI is very similar to a number of cities it outperforms in terms of diversity and average ubiquity, such as Adelaide, Brisbane, Tucson, and Sapporo. This indicates that while Perth may engage in a wider variety of activities, and those activities may be less common, on the whole it is specialized in somewhat low-complexity employment. More encouragingly, Perth's COI is more towards the middle of the distribution for its level of ECI.

Figure 54: ECI vs. COI for Global Cities (Bubble Size by Population, Color by Country)

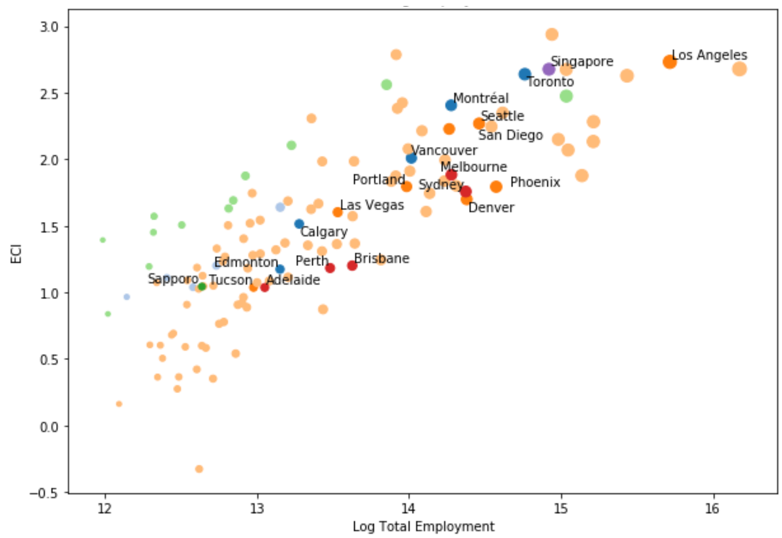


Source: Own construction based on D&B

Figure 55 shows total the natural logarithm ("log") of employment versus ECI, to give a sense of how the sheer size of a city comes into play. While there is an obvious positive relationship between larger total employment and higher ECI, there is also a lot of variation in ECI at each size. Perth skews towards the bottom of the ECI distribution versus cities of a similar size, suggesting that there may be paths to higher complexity that do not necessarily depend exclusively on a higher population. Interestingly, this pattern appears to hold for Australian cities in general.

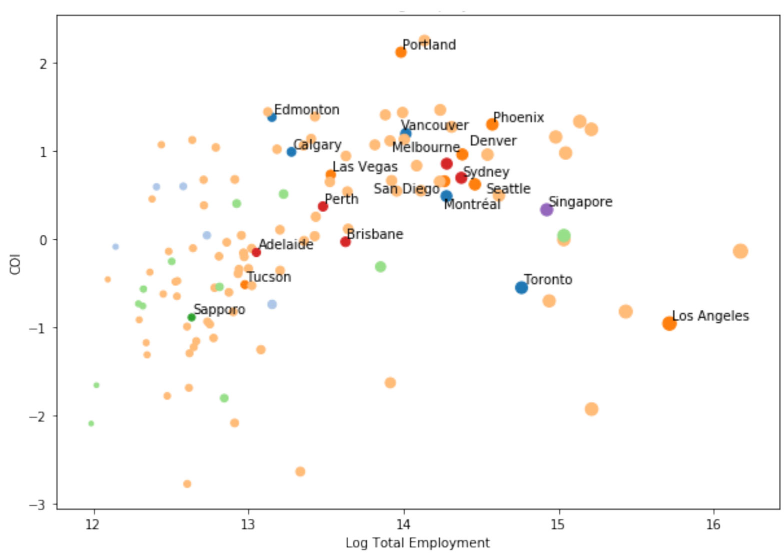
Perth's COI is somewhat higher compared to cities with similar log total employment, as shown in **Figure 56**. It still, however, is geared towards the lower-middle of similarly sized cities. Overall, this suggests that Perth has some latent potential to increase its complexity.

Figure 55: Log Employment vs. ECI for Global Cities (Bubble Size by Population, Color by Country)



Source: Own construction based on D&B

Figure 56: Log Employment vs. COI for Global Cities (Bubble Size by Population, Color by Country)

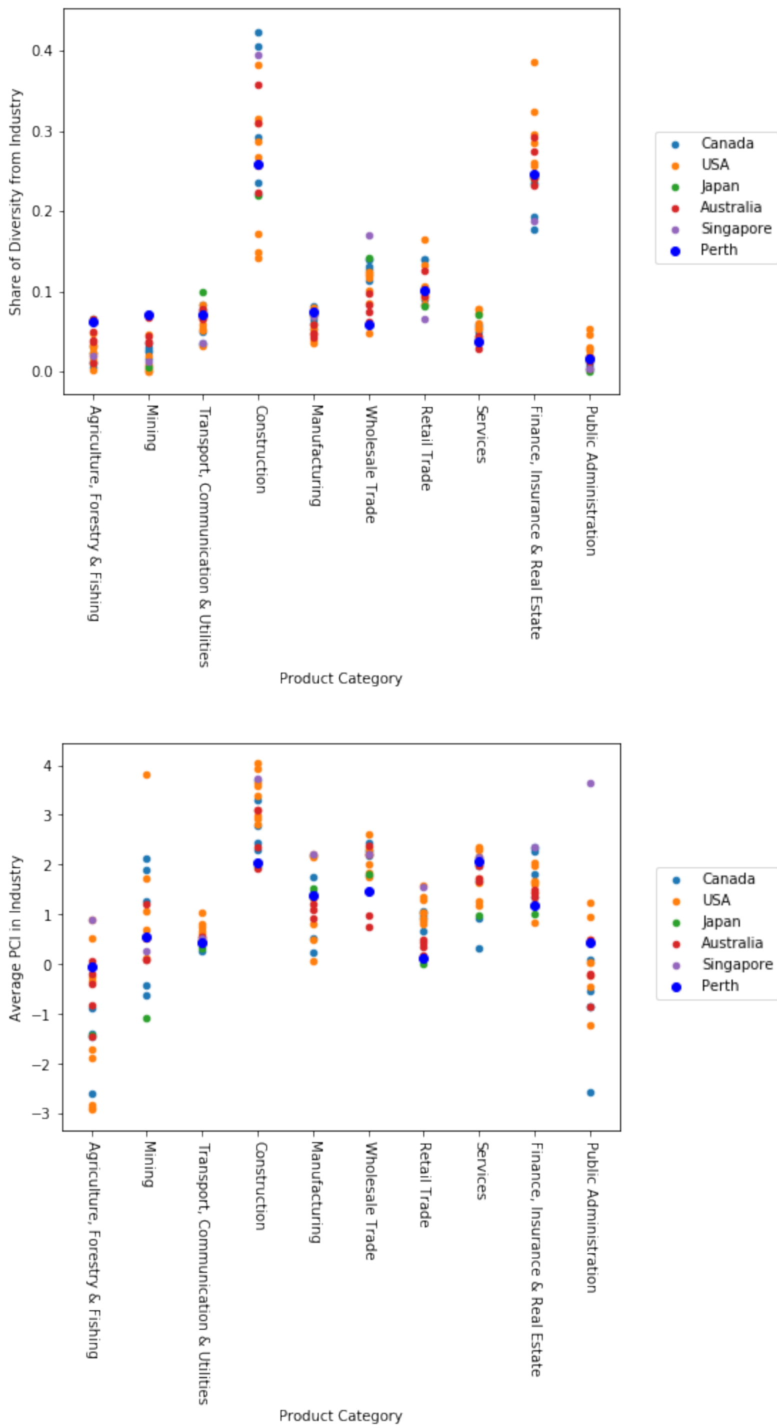


Source: Own construction based on D&B

The composition of Perth's ECI is highlighted in **Figure 57**, which show Perth's share of diversity from each industry as compared to cities in peer states and Perth's average PCI in each industry versus other cities. A few patterns are notable. First, a high share of Perth's diversity comes from agricultural, mining, and manufacturing activities, and a low share comes from services. Second, Perth's agricultural, manufacturing, and services activities are relatively complex. Third, an average share of Perth's diversity comes from the financial sector, while financial activities in

Perth are somewhat low complexity. On the whole, it is especially notable that Perth's other services are very complex but that a very low relative proportion of its diversity comes from these.

Figure 57: Share of Diversity and Average Complexity by Sector, Perth vs. Cities in Peer States



Source: Own construction based on D&B

c) Interpretation of Western Australia's Economic Complexity

There is some evidence that WA has the seeds of nascent capabilities needed for more rapid economic diversification. When one looks beyond the state's large mining and minerals sector and the related construction industry, one finds that WA has diversified capabilities in agriculture and that the state's exports to the developed world in particular include a number of complex manufactured products. Perth stands out as a center of complex activity, with numerous high-complexity activities related to agriculture, manufacturing, and services. In addition, some regions of the state are reasonably complex for their size, often due to activity in agriculture or sometimes manufacturing.

However, WA's potential for economic diversification has yet to be unlocked. Its diversity and economic complexity have been relatively low and have not substantially grown over the observed time period (200-2016 for export-related analysis, plus 2019 for employment-related analysis). WA has diversified into fewer new activities than other large Australian states, both proportionally and in absolute numbers, and its new goods exports account for a very small fraction of its overall export basket. While Perth is reasonably complex in an absolute sense, it has somewhat low complexity for a city of its size. Some other regions have especially low economic complexity and face a low likelihood of economic diversification. WA is an enormously successful economy in many respects, but all evidence suggests that an additional policy push is needed to accelerate the diversification process to make job opportunities and the economy as a whole more resilient to the boom-and-bust cycle of mining-related activity.

It is critical to precisely understand how mining, which is so important to the WA economy, fits into WA's economic complexity. Mining activities in WA are often technically and logistically complex, but they tend not to impart much complex tacit knowledge (or "knowhow") into the WA economy and are therefore unlikely to directly facilitate economic diversification. Given that economic complexity analysis finds this trend for mining all across the world, it is unsurprising to see that WA has not diversified despite having hosted incredibly intense mining activity for an extended period of time. Nevertheless, it would be an enormous mistake to set diversification strategies around a goal of removing mining activity from WA. Any viable economic diversification strategy for WA must build upon its existing economy – not eliminate parts of it.

Looking forward, economic diversification ought to be built out from WA's productive knowhow and not necessarily the raw minerals it extracts. This requires state and local actions to better catalyze new economic activities related to the productive capabilities contained in the economy already, both within and outside of mining. The next section proceeds to leverage economic complexity information discussed to this point in the report to identify promising opportunities to lead diversification.

4. Identification of Diversification Opportunities

a) Main Objective

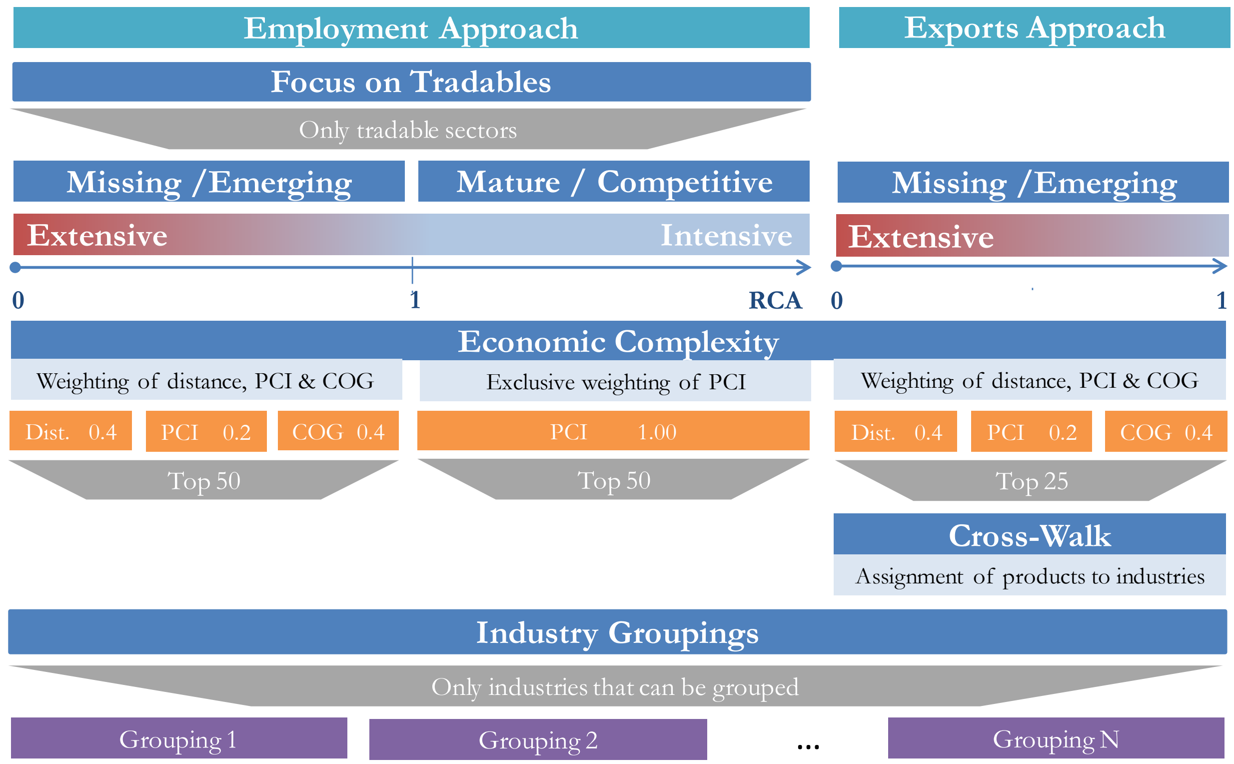
The objective of this exercise is to leverage both the Export and Employment Spaces explored above to develop an initial list of key opportunities for economic diversification. Ultimately, policymakers should use an iterative process to target investment promotion and export development efforts, and should interact with many stakeholders (private sector, academia, industry experts, etc.) to incorporate a variety of perspectives. This exercise is meant to serve as an initial contribution for advancing such a process. Additionally, it is important to note that the economic complexity methodology is one possible approach for identifying diversification opportunities, and the fact that some industries do not come up does not mean they must be excluded from future diversification efforts as there may be other legitimate rationale that make them feasible and/or attractive.

It should be emphasized that what follows is an initial exercise geared towards thinking of a state-level strategy rather than fully independent approaches for each individual region. While it is true that there are sharp regional and even sub-regional differences in economic opportunities, working at a more disaggregated level also includes some limitations. In particular, data might be too "noisy," which in turn could lead to incorrect identification of diversification opportunities. At the same time, units may become "too specialized," thereby underestimating true productive capabilities and complementarities across places. Identification of diversification opportunities may be possible at a more granular level if some of these limitations were explored, but the current analysis is limited to a state-level exercise intended for use by state-level policymakers. However, later on we suggest a way in which complexity metrics can be leveraged to identify roles for individual regions within a coherent state-level diversification strategy.

b) Sector Identification Process

The resources developed in previous sections can be deployed to understand existing and latent areas of comparative advantage because they build on the knowhow, skills and capacities that are already available in the state. This process, which is built on economic complexity methodology, is summarized in **Figure 58** and explained in detail below. Given the relatively small size of the state population and its exposure to sector-specific external shocks, it makes sense to focus efforts on export growth and diversification. All things equal, industries that serve both the domestic and external markets have more potential to grow independently of what happens with WA's mining sector. While the export-based approach necessarily focuses on tradable goods, the employment-based approach can deliberately filter out non-tradable industries. Once the tradable pool of industries is identified, it is possible to consider export growth along two dimensions: the intensive margin, where existing industries can be scaled up; and the extensive margin, where new or nascent industries can be entered. Industries to be targeted on the intensive margin are taken from the pool of industries where RCA is greater than one, while industries to be targeted on the extensive margin are taken from the pool of industries with an RCA less than one.

Figure 58: Sector Identification / Validation Process



Source: Own construction

Strategic industries are selected based on economic complexity metrics – distance, PCI, and COG – in different ways for the intensive and extensive margins. Distance indicates how "nearby" an industry is to industries already present in the state; PCI measures how complex a certain industry is; and COG captures how much closer developing an industry would bring WA to other, more complex industries. All other things equal, out of two industries with the same distance and PCI, the one with a higher COG will be more strategic. While PCI and COG can be positively correlated, there tends to be a negative correlation between distance and each of these variables in places that are not highly complex. This reflects an important trade-off: the most complex industries and those with the best strategic positioning tend to be further away from existing capabilities, while less complex industries tend to be closer.[14]

[14] This negative relationship can be thought of as a risk-return curve. That is, the place may have less chance of success when trying to promote the development of more sophisticated industries, because it requires capabilities that are further away from its initial stock. However, if the place's efforts are successful, rewards are greater because it will have gained greater complexity and/or improved its long-term strategic positioning.

The process for identifying strategic diversification opportunities aims to balance these three dimensions. On the extensive margin, positive weights are given to all three complexity variables. A weight of 0.4 is applied on distance, while the remaining 0.6 weight is applied on PCI (0.2) and COG (0.4). This selection of weights gives greater combined relevance to PCI and COG because of WA's relatively low ECI and COI. On the intensive margin, only the PCI variable is needed because distance and COG are effectively zero for industries where WA already has an intensive presence. However, these criteria are preliminary and are subject to revision pending consolidation with economic development initiatives currently advanced by the state.

Under the employment approach, the process selects 50 industries from both the intensive and extensive margins (100 in total), while under the export approach, it selects 25 products exclusively from the extensive margin. The difference in number of products selected is due to the differing granularity and scope of the product classification systems used for employment versus export analysis. The export analysis uses a variant of the SITC classification system, which has around 600 products in total. In this system WA's current diversity consists of 33 products, so there are a relatively limited number of products that can be realistically considered for the extensive margin. Additionally, most of these exports are low-complexity and are thus not good candidates for expansion on the intensive margin. On the other hand, the employment analysis uses NAICS, which is both finer-grained than SITC and includes services. The NAICS system has around 1100 industries, more than 200 of which WA has a high intensity in and many of which are relatively sophisticated.

At this point, we consolidate findings across the employment and export methodologies in order to be able cluster the strategic industries/products into groupings. For this purpose, we developed a crosswalk to assign the identified products to their corresponding industry. This yields a list of 122 industries, which are variously drawn from the intensive and extensive margins. Finally, these industries are classified into groups of related industries. It is possible to organize 97 of the strategic industries into 5 cohesive groupings. These groups are considered to represent strategic "groupings" and the industries that are not mapped to one of them are dropped. The logic of this step is that resources would be most effectively used if targeted toward collections of industries as opposed to very specific industries.

c) Potential Groupings of Diversification Opportunities

The 97 strategic industries that emerge from this analysis, sorted into five groupings, provide an initial list of strategic opportunities to support export diversification. These strategic groupings are the following: Primary Industries and Related; Intermediate Inputs and Materials Manufacturing; Technology and Advanced Manufacturing; Tourism; and Professional Services. **Figure 59** shows these groupings and how they can be divided into narrower thematic sub-areas (sub-groupings). Annex 3 shows the different industries that make up each of these groupings and sub-groupings. It should be noted that these groupings are preliminary in nature and could be adjusted based on feedback from stakeholders, the state's strategic priorities and other relevant considerations.

Furthermore, industry featured in Annex 3 should be considered as indicative as the type of potential capabilities inherent of the states and not necessarily precise recommendations of activities to actively pursue.

Figure 59: Identified Groupings and Sub-Groupings

Grouping / Sub-Grouping	# of Industries
Intermediate Inputs and Materials Manufacturing	**17**
Chemical Manufacturing	3
Metal and Metal Products Manufacturing	9
Nonmetallic Mineral Product Manufacturing	5
Primary Industries and Related	**11**
Beverage and Tobacco Product Manufacturing	2
Fishing	3
Food Manufacturing	2
Fruit and Tree Nut Farming	2
Wood Product Manufacturing	2
Professional Services	**19**
Consulting and Research Services	5
Engineering and Architectural Services	4
IT Services	5
Legal Services	2
Specialized Design Services	3
Technology and Advanced Manufacturing	**30**
Computer and Electronic Product Manufacturing	9
Health Product Manufacturing	2
Machinery Manufacturing	13
Transportation Equipment Manufacturing	6
Tourism	**20**
Educational Services	5
Food and Transportation	9
Health Services	6

Source: Own construction

5. Additional Perspectives on Diversification Opportunities

a) General Considerations

Having identified several key economic activities in which WA may be able to diversify its economy, it is important to understand the strategic opportunity they offer in more depth and the role individual regions could play in a state-wide strategy. In particular, it can be useful to evaluate how viable and how attractive each diversification opportunity is and how they fit with each region's current base of productive knowhow. The objective of this section is two-fold: (i) to offer an initial analysis of relevant preliminary viability and attractiveness factors that are informed by Western Australia's comparative advantages and disadvantages, features of the labor market, and geography; and (ii) open-up a conversation of both the opportunities and challenges of pursuing a state-wide diversification strategy with a substantial footprint across all regions.

WA's diversification strategy should be locally owned, and both its development and implementation should be iterative and involve many stakeholders in order to maximize information and actions. Therefore, this analysis should be viewed as a preliminary input meant to stimulate a broader process.

b) Possible Viability and Attractiveness Factors

Below we describe and quantify several factors that could provide practical insights for further evaluating the viability and attractiveness of the 97 industry opportunities identified in the preceding section, both at the state level and for particular regions. These are based on observations of WA's factors of productivity and known differences between industries, but this list could be greatly enhanced by incorporating strategic priorities, existing capabilities and other concrete constraints in the state. The viability factors aim to capture indicators that the industry is likely to thrive in the state (or a specific region in question), while the attractiveness factors aim to quantify ways in which some industries may be more desirable to the state for the benefits that they would be likely to provide.

Measuring these factors is not always straightforward. In many cases, we use global data or data from the U.S. economy – which has reliable data and highly diverse productive structures – to provide industry-level measurements under the assumption that these will tend to hold within the same industry across developed economies. The raw scores for each industry on each of these factors are presented in Annexes 4 and 5.

<u>The viability factors proposed are the following:</u>

- *Current presence in WA*: Industries that have already achieved some scale in WA, even if with RCA<1, are likely to be easier to develop further, and furthermore can be investigated to ascertain the barriers to their expansion. The existing presence of an industry can be measured with RCA is therefore used again here as a viability factor.

- *Current presence in peer states*: If an industry has been developed successfully in similar contexts, it is likely to be relatively easier for WA to develop as well. A high presence in peer states does not guarantee the success of the industry in WA, but it should make it more likely. The average RCA in peer states is used to measure this factor.
- *Dependency on utilities*: Preliminary analysis carried out by the Growth Lab team identifies water and electricity may be scarce factors in WA, and particularly in several regions of the state. Industries that are not intensive in these utilities may therefore be more viable. To get an indication of this factor, the percentages of intermediate consumption from water and electricity in each industry is tabulated based on data from the US Input-Output Tables. Similarly, the dependency on other missing key inputs could be considered in further iterations.
- *Ability to access occupational inputs:* Developing a new industry requires access to a labor market that can support it. To measure performance in this variable, the scheme considers the number of occupations estimated to be (i) intensively required by the industry in question, and (ii) are (implicitly) missing or not accessible in the state. The methodology used to make these estimates is also explained in detail in Annex 6. Of course, if certain types of workers are not available at present, they may migrate to the state to fill these jobs or workers with similar skill sets may be retrained. But, all things equal, industries that closely match the current occupational vector will be more viable.
- *Ability to access intermediate inputs*: A crucial element for the development of any productive activity is the ability to access the non-labor inputs it requires. To measure performance on this variable, the scheme considers the number of inputs estimated to be (i) intensively required by the industry in question, and (ii) (implicitly) missing or not accessible in the state. It assumes that if other activities that demand the same inputs have a significant presence in WA, then it is likely that the new industry will also be able to access them. WA can also import some of the inputs that are not currently available. But, again, all things equal, industries where inputs are currently available will be more viable. Details of the procedure used to calculate this measure are presented in Annex 7.

<u>The attractiveness factors proposed are the following</u>:

- *Ability to pay high salaries*: Attracting industries that pay high wages would be beneficial for Western Australian workers.[15] To this end, the wage that each industry pays relative to the average of the rest of the U.S. economy is calculated using information from the Bureau of Labor Statistics (BLS).
- *Ability to translate into an export activity*: Given the small size of the state population and the non-tradable economy's vulnerability to the boom-bust cycle and external shocks, it makes sense to focus efforts on export growth and diversification. All things equal, industries that

[15] Given the wage premium in WA relative to the rest of the country, this could also be considered a viability factor since lower-wage industries may struggle to find workers.

serve both the domestic and external markets have more potential to grow independently of what happens with WA's mining sector. This is partially accounted for earlier in the analysis but can be further explored here. The scheme thus considers each industry's propensity to export by observing percentage of worldwide employment in each industry that is concentrated in exporting firms, which is calculated using data from Dun & Bradstreet.

- *Global FDI flows*: Foreign Direct Investment (FDI) can have multiple benefits, including a high degree of knowledge spillovers. This alone makes industries with high rates of FDI more attractive. The relative size of FDI flows globally is also a useful proxy for global demand for the industry, as FDI is responding to an expectation of growing demand. This factor is measured according to the total value of the FDI that worldwide has gone to each diversification opportunity in recent years (2003-2015). Data from fDi Markets is used to construct this measure.[16] Details of the procedure used to calculate this measure are presented in Annex 8.
- *Knowledge-intensive FDI flows*: FDI is especially useful if it directly fosters the development of new capabilities in the investment destination. We therefore include a measure that is similar to the previous FDI metric, but only considers FDI flows that involved setting up an office in the investment destination, engagement in R&D activities, or engagement in design, development, and testing activities. Details of the calculation procedure for this metric are presented in Annex 8.
- *Ability to thrive in remote places*: WA is a remote state with many very remote regions. For some industries, remoteness can be a limiting factor (for example, if transportation costs are high or if close geographical proximity to other industries). Therefore, industries that are generally able to succeed in remote places may be more attractive for state-level policymakers. We estimate this ability by calculating a "remoteness coefficient," which is a statistical association between industry RCAs and the remoteness of places to population centers using D&B information at a U.S. county level. The methodology used to estimate remoteness is the same as the one used in the peer selection process, which is explained in Annex 1. Note that this may be considered an attractiveness feature at the state level (out of a desire to develop industries that can succeed in regions) but would become a key viability factor if a similar analysis were conducted for a remote region.

c) Normalization and Visualization of Factors

The above measures of attractiveness and feasibility can be normalized for easier comparison, which is done according to the following formula:

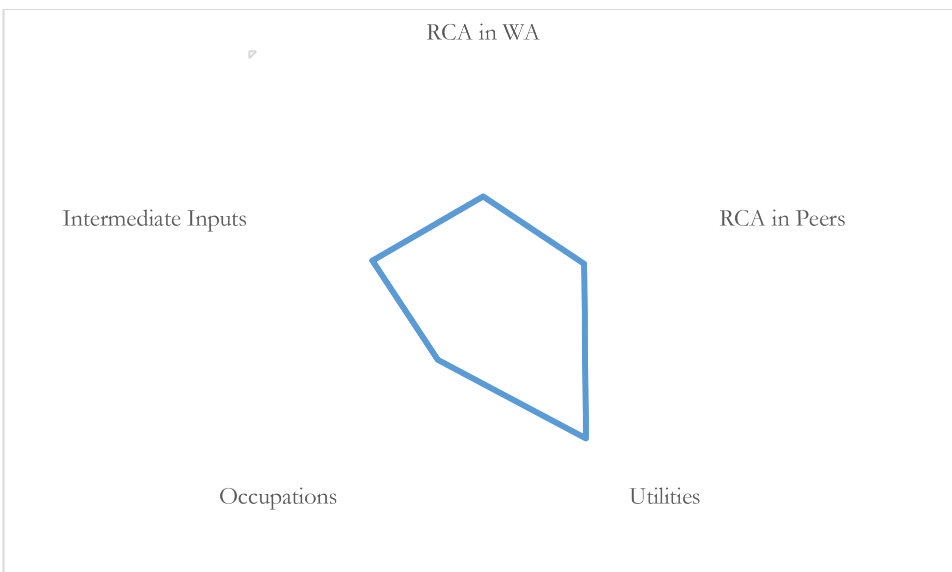
[16] Although this information is available for a classification system different from the one used here and for a less granular aggregation level, a mechanism that allows the assignment of FDI flows to the industries of interest is developed. The methodology is explained in detail in Annex 8.

$$NV_{ij} = 5 + 2 * \left[\frac{V_{ij} - mean_j(V_{ij})}{sd_j(V_{ij})}\right]$$

where NV_{ij} is the (normalized) value of industry i in factor j, and $mean_j(V_{ij})$ and $sd_j(V_{ij})$ are the mean and standard deviation, respectively, of all values for factor j. Normalized values that turn out to be less than 0 and greater than 10 are adjusted upward or downward until these limit values are reached. Consequently, the maximum normalized value for any factor is 10, the minimum is 0 and the average is close to 5.[17]

This normalization also facilitates the visualization of the factors that improve and worsen the viability and attractiveness of the different opportunities for diversification. As an example, **Figure 60** and **Figure 61** show the performance of the industry "Electromedical and Electrotherapeutic Apparatus Manufacturing" in the various viability and attractiveness factors, respectively. On the one hand, electromedical device manufacturing is relatively consistent with WA's utility costs. However, the low RCA of WA and peers in electromedical device manufacturing suggests that some capabilities and comparative advantages may not be well-supplied. In terms of attractiveness, electromedical device manufacturing scores fairly well on the wages, remoteness, and FDI knowledge factors, and very highly on the export factor.

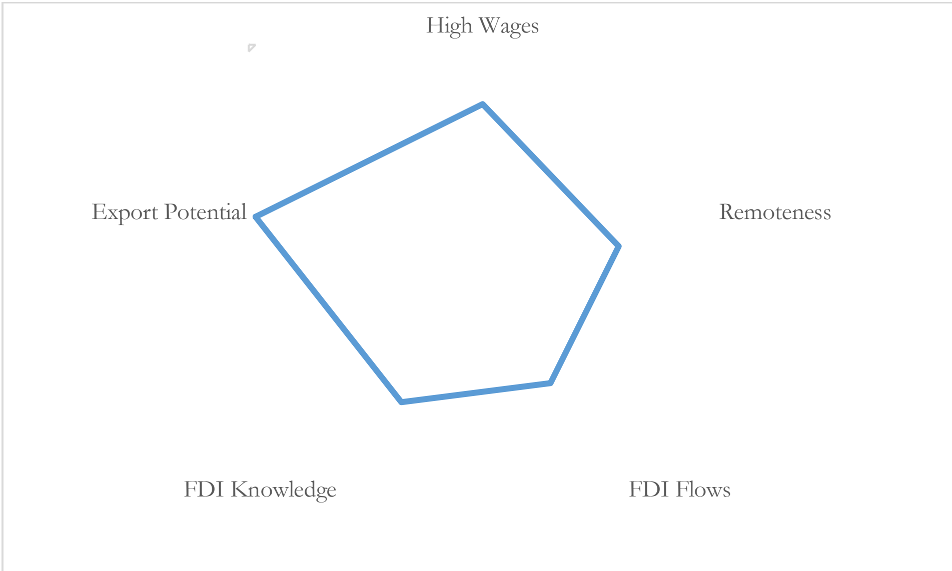
Figure 60: Viability Factors, Normalized Values – Electromedical Device Manufacturing



Source: Own construction based on Dun & Bradstreet and U.S. Input-Output Table

[17] It is exactly 5 if no upward or downward adjustments are necessary.

Figure 61: Attractiveness Factors, Normalized Values – Electromedical Device Manufacturing



Source: Own construction based on Dun & Bradstreet, U.S. BLS and fDi Markets

Systematically repeating this exercise across all potential industries, may inform the strategic prioritization of these potential industries. However, as previously stated, the value of this approach could be greatly enhanced by considering other context specific variables, current capabilities and strategic priorities.

d) Introducing Criteria for Regional Participation in a State-Wide Strategy

Ideally WA's state-wide diversification strategy should allow for increased diversification across all of its regions. One potentially useful input toward this would be to quantify regional suitability vis-à-vis each diversification opportunity based on complexity metrics. Namely, by attempting to identify the regions that have a base of productive knowhow that most closely resembles the one that is required to develop them. As for the state-level, this complexity approximation could be complemented with viability or attractiveness factors that are relevant and measurable at a sub-state level. Stakeholder feedback and qualitative findings may be particularly useful in subsequent iterations of this exercise.

In this preliminary exercise we are only considering complexity metrics and employment metrics. In particular, we utilize using four variables: (i) the RCA that each region displays for each industry; (ii) the overall number of people that the region currently employs in the industry; (iii) the distance measure that between each industry the region's base of productive knowhow; and (iv) the complexity outlook gain a region experiences for adding that industry. The first two measure the "strength" of each region in the industry in question, the third evaluates the knowhow that the region expresses in the presence of similar industries, and the fourth evaluates how useful an opportunity would be for each region. For the purposes of this exercise, these four values are normalized and the following weights are used: 35% to RCA, 15% to employment, 15% to distance, and 35% to complexity outlook gain. Finally, for each industry the three regions that have a better performance in this score are identified.

Annex 9 details the match of each of the potential industry to three best-ranked regions in the state. It could be worthwhile to enhance this exercise by considering other criteria that is relevant at a regional level, as well as existing strategic initiatives. Additionally, other complexity approaches could also add valuable information in order to structure a more balanced and inclusive growth and diversification strategy.

6. Conclusions and Next Steps

This economic complexity report has explored the productive structure of the economy of Western Australia and identified an initial list of promising opportunities for economic diversification. The analysis utilizes two custom-made network tools – an Export Space and an Employment Space – to understand both productive capabilities at the state-level and how capabilities are dispersed across regions of the state. The report also introduces data on several relevant viability and attractiveness factors for each of the promising industry opportunities and information on which regions have occupation structures that match industry needs. The report aims to provide new information that government officials and other stakeholders can use to help strategize how to better catalyze diversification in the state. The information is intended to be used in combination with other quantitative analyses of diversification opportunities and context-specific knowledge of state and local institutions.

WA's productive structure is characterized by an export-intensive mining sector with a particular concentration in iron ore destined for China and other East Asian countries. The state's employment in construction is also high, especially in comparison to non-Australian peer states, which is likely related to the heavy presence of mining in the economy and its construction demand. If one looks beyond the mining sector, WA has several revealed comparative advantages in agriculture, particularly wheat, meat, and select seafood, and the state exports a significant range of agricultural products in higher per capita terms than the rest of Australia. The scale of these raw material and agriculture products makes it easy to overlook that WA also has established productive capacities for a range of manufactured products, including in chemicals, materials, machinery, and transportation components. Many of these products appear to be inputs for the local mining and agriculture sectors, but many are also exported to the rest of the developed world. A large proportion of exports bound for the United States, for instance, are manufactured goods.

Regions within the state vary considerably in scale and economic structure, with mining, agriculture, manufacturing, construction, and other services being particularly intensive in some regions and particularly absent in others. Meanwhile, although mining makes up a large share of WA's employment versus other places, the vast majority of jobs in the state are not in mining or even construction, but largely in other services including retail, food and accommodation, professional and technical activities, education, and healthcare. This is true even for mining-intensive regions. Some of these services jobs are mining related, but many more are in non-tradable services that expand and contract with the resource-driven growth of the state economy.

The state's overall productive structure is of low economic complexity, meaning that knowhow embedded in industries that are present in WA do not stimulate diversification as easily as other similar states, both in Australia and globally. This reflects a pattern where employment and exports are concentrated in low-complexity sectors overall and in low-complexity activities across all sectors. This helps to explain why diversification of WA's exports has been very limited over the last decade and underscores the need for the state to take a strategic approach to catalyzing economic diversification if the future is to look different. Not surprisingly, Perth's productive structure is by far the most connected to new opportunities among the regions, followed much more closely by South West than the others. A close look at Perth shows that the state's economic and population center has a level of economic complexity similar to other global cities but somewhat low for its population size. The capability base for economic diversification in Perth appears to be strong.

Despite being at a disadvantage for diversification versus other states, applying a tailored process to identify the most promising industries for diversification still yielded a wealth of promising opportunities. The results of the industry identification process naturally grouped into 20 fairly specific sub-groupings, which we have summarized into these five main groupings:

- **Primary Industries and Related** ***(~18% of opportunities)*** – This group captures fishing, fruits, food and beverage manufacturing, and wood products. Most of the specific industries included in this group are already produced with a comparative advantage in WA and their inclusion signals that there is high potential that they can grow significantly and that continued diversification opportunities can emerge through the companies that are already active in WA. Production and potential production appear to be spread significantly across the state.
- **Intermediate Inputs and Materials Manufacturing** ***(~11% of opportunities)*** – This group includes a variety of chemicals, plastics, metals, and construction materials. The products in this group can serve the state's mining and manufacturing industries but can also access much larger markets outside of the state. They represent a mix of products that are already produced to some extent in the state and products which are either nascent or not yet produced in WA. Based on occupational structure data, opportunities appear to be strongest in regions that are closer to the population centers in the southwest of the state. In the context of COVID-19 these opportunities are especially noteworthy as industries in WA and the rest of Australia may look to secure more domestic suppliers.
- **Technology and Advanced Manufacturing** ***(~31% of opportunities)*** – This group emerged as one with the largest number of industry opportunities and one where few of the industries identified are currently present in significant scale. The specific products and industries signal many opportunities for existing companies and new entrants, in particular to innovate in serving the unique and changing needs of mining, agriculture, forestry, fishing, construction and healthcare in WA and Australia as a whole. While current occupational structures are most aligned with these opportunities in Perth, the South West, and the Wheat Belt, there is potential across all regions of the state. This group includes the types of products that will provide innovative solutions to the problems that the world faces today, including the current pandemic.
- **Professional Services** ***(~20% of opportunities)*** – This group includes a range of high-skill services in engineering and architecture, information technology, legal services, design

services, and research and consulting. These services go hand-in-hand with more innovation in technology and manufacturing. The majority of these opportunities have a limited foothold in the state at present, suggesting that inter-state and international migration might be important for expanding the diversity of professional services in WA. Modern telecommunications make these opportunities possible even in more remote areas of the state. As a result of the COVID-19 pandemic, it is likely that remote work will be more prevalent in the future as businesses have learned to utilize this option.

- **Tourism** ***(~21% of opportunities)*** – This group contains not only traditional tourism opportunities and the food and transportation activities that go along with tourism, but also includes education and healthcare opportunities (in the spirit of these as education and healthcare service exports). There are substantial opportunities here to serve the demand of the rest of Australia and international demand for travel experiences, quality education, and healthcare services, especially for ageing populations who may choose to relocate. All regions of the state can capture more of these opportunities, and doing so requires significant state-regional collaboration to capture demand and address supply constraints. It is noteworthy that educational services are currently concentrated in and around Perth, which likely limits the state's ability to capitalize on education exports and, perhaps more importantly, limits the innovation potential of regions.

Looking across the opportunities identified by the analysis, there is a clear potential for the state to build on its "upstream" innovation capabilities to serve the demand of its biggest industries, including mining and agriculture, as well as healthcare, fishing and forestry, among others. This makes sense given that the WA's companies and entrepreneurs should be in the best position to develop and re-configure technologies that these industries need to keep up with a changing world and new global challenges, including impacts from climate change. Due to the state's remoteness, it has above average advantages to strengthen backwards linkages from its major industries because of the increased advantage of being close to them. It is noteworthy that this pattern appeared across the results rather than "downstream" opportunities that are commonly assumed to exist in resource-rich places. WA's best opportunities appear to center around serving the demand of very productive industries and innovating to serve the future needs of the rest of the world, rather than competing with the rest of the world for expensive raw materials currently exported from the state in order to add value to them.

Finally, the results point to a need to re-imagine the structure of economic relationships between the Perth urban agglomeration and the rest of the state. The best opportunities for diversification and better job opportunities emerge not from one region or another but rather from the interaction between regions. As stakeholders incorporate the results of this report into strategy, policy and public investment decisions, it will be critically important to focus less on precisely what industries are identified and where, and more on how to catalyze the emergence of these opportunities across the state as a whole. The process of diversification happens through businesses exploring how they can expand on products that they make and services that they provide in a place and, often, through businesses in one place determining that they can do what they currently do in a new place. In both cases, the process involves businesses and entrepreneurs discovering opportunities and taking risks. This report aims to enhance the roles that the state can play in supporting discovery, lowering risks, and providing public goods that the private sector needs in order to succeed in new business activities.

The process and results from this analysis are intended to be reviewed and improved through further collaboration between the Growth Lab and Government of Western Australia, such that the results can be put to use and the process can be improved over time and repeated as conditions change. Opportunities abound for the state and its regions, but capitalizing on these opportunities will require new forms of collaboration between public sector institutions, between the public sector and private sector, and between Perth and the regions. This report is intended to lay the foundation for institutional innovations and policy actions to be developed toward this end.

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Annex 1: Peer Selection Process

The availability of geocoded firm-level data from D&B creates an important analytical opportunity: the comparison of employment patterns in WA to those in subnational entities from other countries. A set of selection criteria was thus developed to choose peer locations that can serve as comparison points or economic role models for the state. Specifically, the criteria of data availability, income per person, population of the entire state, population of the largest city, population density, remoteness, and similarity of industry-wise employment concentration were considered. First, prospective peers were put through a filtering process to eliminate unsuitable candidates, and then an index of dissimilarity was constructed. The exact steps in this procedure are outlined below, including a quick check for how the peer group list could change if different thresholds were applied to the determining criteria.

a) Data Availability

The set of countries from which potential peers could be drawn is limited by the data coverage of D&B. Specifically, data coverage extends to the following countries: Argentina, Australia, Austria, Bangladesh, Belgium, Bhutan, Bosnia and Herzegovina, Brazil, Bulgaria, Canada, Chile, Costa Rica, the Czech Republic, Denmark, Djibouti, Estonia, Finland, France, Germany, Greece, Guatemala, Honduras, Hungary, Italy, Japan, Jordan, Latvia, Lesotho, Lithuania, Madagascar, Myanmar, Nepal, Norway, Pakistan, Papua New Guinea, Poland, Portugal, Russia, Slovakia, Slovenia, South Africa, South Korea, Spain, Sri Lanka, Sweden, Tunisia, Uruguay, the United States of America, and Uzbekistan. Prospective peer states could only be drawn from this set of countries.

b) Filtering by Country-Level Variables

From this list of candidates, a narrower list of prospective countries that match WA on important dimensions was produced. First, countries were required to have a GDP per capita of at least USD $35,000 USD. Second, countries were required to have at least one city with a metro-area population above 2 million. This narrowed the list of countries to Australia, Austria, Canada, France, Germany, Japan, and the US.

c) Filtering by State-Level Variables

Next, a list of prospective state-level peers was drawn from these countries on the basis of meeting certain state-level criterion. First, states were required to have a population density below 100 people per square kilometer (those which did not meet this criterion either represented city-level entities, such as Vienna, or densely-populated states, such as Miyagi Prefecture in Japan). Second, states were required to have at least one city with a metro-area population above 1.5 million. This yielded the following list of state-level entities: New South Wales, Australia; Victoria, Australia; Queensland, Australia; Alberta, Canada; British Columbia, Canada; Ontario, Canada; Quebec, Canada; Hokkaido, Japan; Arizona, USA; California, USA; Colorado, USA; Georgia, USA; Illinois, USA; Indiana, USA; Michigan, USA; Missouri, USA; Nevada, USA; North Carolina, USA; Oregon, USA; Tennessee, USA; Texas, USA; Virginia, USA; Washington, USA; and Wisconsin, USA.

d) Index of Dissimilarity to Western Australia

Finally, an index of each state's dissimilarity to WA was constructed, and up to six states from each country were selected as peers that scored the highest on this index (in practice, this is mainly to narrow down the number of U.S. states, as there are already relatively few candidate peers from other countries.) This index of dissimilarity was constructed based on three measures: the similarity of a state's employment profile to WA; the similarity of a state's remoteness vis a vis the population of world cities to WA; and the similarity of a state's remoteness vis a vis the GDP of world countries and regions to WA.

The first of these measures, the similarity of a state's employment profile compared to WA, was computed using data from D&B. The algorithm that was used proceeds as follows:

1. Economic complexity calculations are run on global state-level employment data to obtain the list of industries for which each state has a revealed comparative advantage.
2. The proximity of different industries is calculated using U.S. city-level data. In this process, the city-level data is filtered so that city-level industries with fewer than five employees will not count as revealed comparative advantages.
3. Each state is compared to WA, one at a time. For each of WA's revealed comparative advantages, the most proximate industry in the partner state's revealed comparative advantages are identified. The vice versa is also performed, looking from the partner state to WA. All these proximities are then averaged. This produces a measure of how similar each state's employment-wise revealed comparative advantages are to WA.

The second of these measures, each state's remoteness vis-a-vis the population of world cities, is calculated as follows:

1. A database of the world's 200 largest cities, including both population and GPS coordinates, is obtained.
2. A database of the GPS coordinates of each state's centroid is obtained.
3. The distance from each state to each city in kilometers is calculated.
4. Each distance measure is converted to a measure of proximity by subtracting each distance from the maximum observed distance.
5. Each measure of proximity is put to the power of twenty. This is done to make the proximity measure more sensitive to nearby cities as opposed to cities on the other side of the globe.

6. The proximity measure is normalized to a range of zero to one by dividing by the maximum proximity score.
7. Each city's population is normalized to a range of zero to one by dividing by the maximum population.
8. The dot product of the proximity matrix and population vector is taken to obtain each state's weighted proximity to population centers. This measure is divided by the maximum score to normalize it to a range of zero to one. This serves as a population-based remoteness score.

The third of these measures, each state's remoteness vis a vis the geography of world GDP, is calculated as follows:

1. Subnational GDP data is obtained wherever possible from OECD data. For countries without subnational coverage, national GDP is obtained. This is used to create a database of different economies around the world, with entries on GDP and the GPS coordinates of their centroids.
2. A database of the GPS coordinates of each state's centroid is obtained.
3. The distance from each state to each economic region in kilometers is calculated.
4. Each distance measure is converted to a measure of proximity by subtracting each distance from the maximum observed distance.
5. Each measure of proximity is put to the power of twenty. This is done to make the proximity measure more sensitive to nearby economic regions as opposed to regions on the other side of the globe.
6. The proximity measure is normalized to a range of zero to one by dividing by the maximum proximity score.
7. Each region's GDP is normalized to a range of zero to one by dividing by the maximum GDP.
8. The dot product of the proximity matrix and GDP vector is taken to obtain each state's weighted proximity to regions of economic activity. This measure is divided by the maximum score to normalize it to a range of zero to one. This serves as a GDP-based remoteness score.

Each state *i*'s index of dissimilarity to WA is then calculated as follows:

$$\begin{gathered} Dissimilarity\ Index_i = \\ 2 \times (Employment\ Similarity_i)^2 \\ + (Population\ Remoteness_i - Population\ Remoteness_{WA})^2 \\ + (GDP\ Remoteness_i - GDP\ Remoteness_{WA})^2 \end{gathered}$$

Notice that the difference between the remoteness score for the state and that for WA is used for the latter two measures. Conversely, the employment similarity measures is already calculated in terms of relative similarity to WA, so no difference needs to be taken. Notice also that the weight of the employment similarity scores is multiplied by two so that it balances the influence of the two remoteness-based measures.

Taking up to the top six states from each country in the previous list yields the following final list of peers: New South Wales, Australia; Victoria, Australia; Queensland, Australia; Alberta, Canada; British Columbia, Canada; Ontario, Canada; Quebec, Canada; Hokkaido, Japan; Arizona, USA; California, USA; Colorado, USA; Nevada, USA; Oregon, USA; and Washington, USA.

e) Alternative Choices of Filtering Thresholds

Four thresholds are used to filter for candidate states: country-level GDP per capita; country-level largest city population; state-level population density; and state-level largest city population. While any of these could be changed, we see the first three as having very little practical space for adjustment without undermining the purpose of the exercise. Meanwhile, it is feasible that relaxing the last threshold could be used to obtain reasonable alternative peers.

On the first criterion, adjusting the GDP per capita threshold would not yield many sensible comparators. Slightly lowering the GDP per capita threshold for countries from $35,000 USD to $30,000 USD, for instance, would lead to Italy, Spain, and South Korea being considered as comparators – none of which are particularly remote nor engage in much mining. Dramatically lowering this threshold to include countries like Argentina, Russia, Brazil, and South Africa (that engage in some mining) is likewise problematic, in this case because the costs and availabilities of inputs, particularly labor, are typically very different in developing versus developed countries. It would be difficult to use a Brazilian state, for instance, as a comparison point to develop a diversification strategy for WA given its radically different economic environment. Given that all the countries with GDP per capita levels above $35,000 USD for which data is available have at least one city with a population above 2 million, we feel it would similarly make little sense to adjust the country-level city size requirement.

Relaxing the state-level population density threshold is likewise unlikely to yield reasonable alternative peers. States with population densities above 100 people per square kilometers are typically quite densely populated and are unlikely to serve as good comparison points for WA. California, for instance, has a population density of 97 people per square kilometer and is the 11th most densely populated US state. It is arguably just at the edge of reasonable comparators for WA, and even then only if one considers it as a long-term aspirational peer.

The threshold most open to relaxation is the state-level city size. While the existing threshold, 1.5 million, is already slightly smaller than Perth, one might imagine that relatively rural states could serve as valid comparison points for WA as a whole and especially for its regions. Three alternative sets of peer states are thus presented below, with minimum population of the largest city thresholds of 1 million, 0.5 million, and 0.1 million. Changing these thresholds changes the state list slightly, but not to the point that some certain comparisons (i.e. Alaska) would appear.

Minimum City Size: 1,000,000

State	Country	Population of Largest City (Millions)	Dissimilarity Score
Queensland	Australia	2.5	0.010
New South Wales	Australia	5	0.018
South Australia	Australia	1.3	0.020
Victoria	Australia	4.3	0.027
British Columbia	Canada	2.5	0.166
Alberta	Canada	1.5	0.194
Quebec	Canada	4.1	0.289
Ontario	Canada	5.9	0.380
Hokkaido	Japan	2.3	0.532
Hawaii	USA	1	0.222
Washington	USA	3.9	0.281
Oregon	USA	2.5	0.292
Nevada	USA	2.2	0.379
Utah	USA	1.2	0.398
California	USA	13.1	0.402

Minimum City Size: 500,000

State	Country	Population of Largest City (Millions)	Dissimilarity Score
Queensland	Australia	2.5	0.010
New South Wales	Australia	5	0.018
South Australia	Australia	1.3	0.020
Victoria	Australia	4.3	0.027
British Columbia	Canada	2.5	0.166
Alberta	Canada	1.5	0.194
Manitoba	Canada	0.8	0.267
Quebec	Canada	4.1	0.289
Ontario	Canada	5.9	0.380
Hokkaido	Japan	2.3	0.532
Hawaii	USA	1	0.222
Washington	USA	3.9	0.281
Oregon	USA	2.5	0.292
Idaho	USA	0.7	0.304
Nevada	USA	2.2	0.379
Utah	USA	1.2	0.398

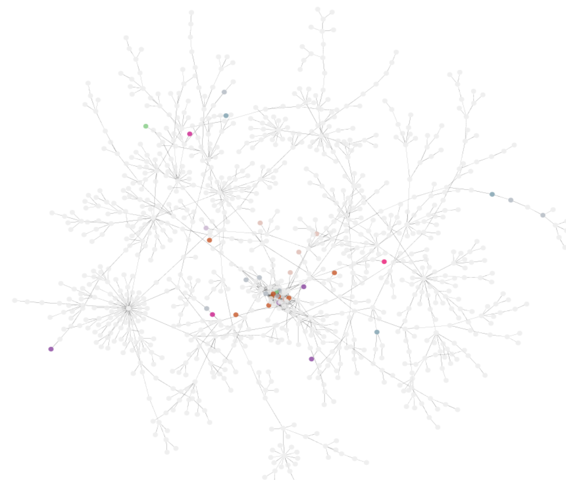
Minimum City Size: 100,000

State	Country	Population of Largest City (Millions)	Dissimilarity Score
Queensland	Australia	2.5	0.010
New South Wales	Australia	5	0.018
South Australia	Australia	1.3	0.020
Victoria	Australia	4.3	0.027
Northern Territory	Australia	0.2	0.051
British Columbia	Canada	2.5	0.166
Alberta	Canada	1.5	0.194
Newfoundland	Canada	0.2	0.195
Saskatchewan	Canada	0.3	0.219
Manitoba	Canada	0.8	0.267
Hokkaido	Japan	2.3	0.532
Iwate	Japan	0.3	0.831
Akita	Japan	0.3	0.869
Hawaii	USA	1	0.222
Washington	USA	3.9	0.281
Oregon	USA	2.5	0.292
Montana	USA	0.2	0.301
Idaho	USA	0.7	0.304
North Dakota	USA	0.1	0.357

Annex 2: Employment Space, WA Regions

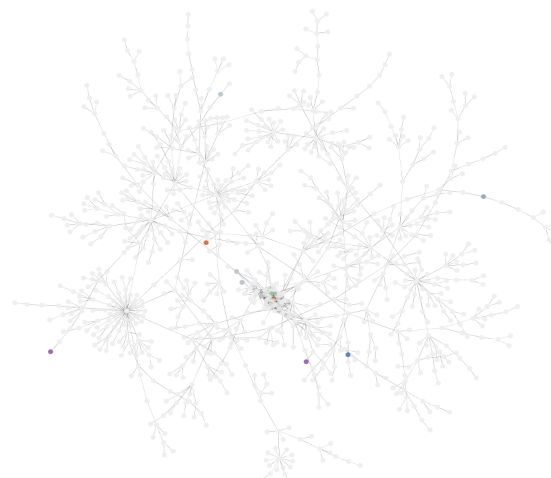
Perth

South West



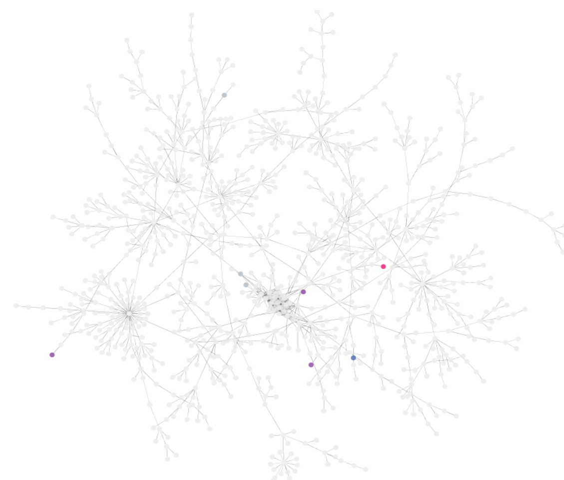
Peel

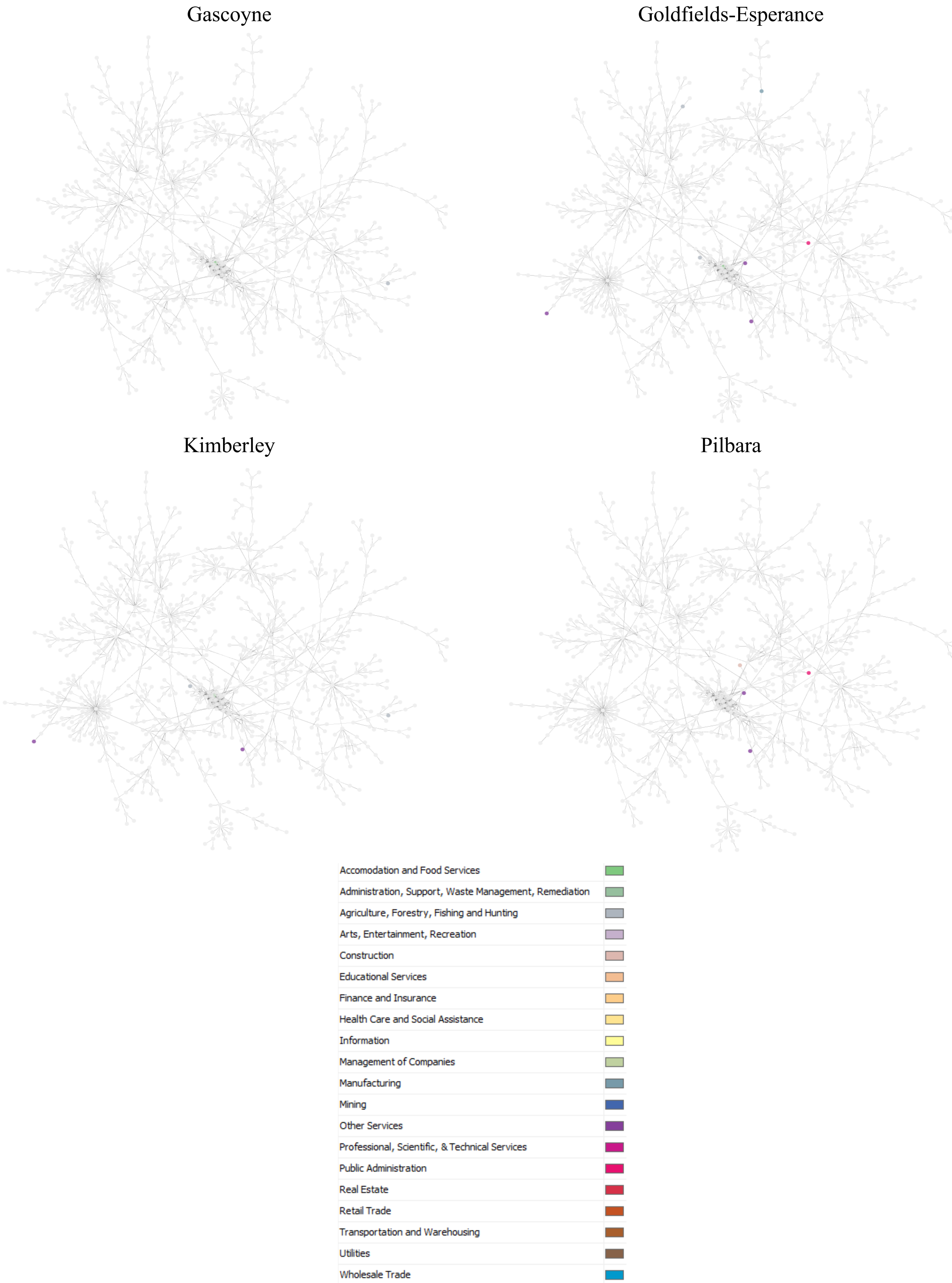
Great Southern



Wheat Belt

Mid West





Source: Own construction based on D&B.

Annex 3: Industry Groupings and Sub-Groupings

Theme	Subtheme	Industries in which WA shows a RCA and can grow in the intensive margin	Industries that WA can develop to foster growth on the extensive margin
Primary Industries and Related	Beverage and Tobacco Product Manufacturing	- Breweries - Tobacco Manufacturing	
Primary Industries and Related	Fishing	- Finfish Fishing - Shellfish Fishing - Other Marine Fishing	
Primary Industries and Related	Food Manufacturing	- Ice Cream and Frozen Dessert Manufacturing	- Coffee and Tea Manufacturing
Primary Industries and Related	Fruit and Tree Nut Farming	- Citrus (except Orange) Groves - Fruit and Tree Nut Combination Farming	
Primary Industries and Related	Wood Product Manufacturing	- Wood Office Furniture Manufacturing	- Custom Architectural Woodwork and Millwork Manufacturing
Intermediate Inputs and Materials Manufacturing	Chemical Manufacturing	- All Other Miscellaneous Chemical Product and Preparation Manufacturing	- Plastics Material and Resin Manufacturing - Adhesive Manufacturing
Intermediate Inputs and Materials Manufacturing	Metal and Metal Products Manufacturing	- Rolled Steel Shape Manufacturing - Metal Window & Door Manufacturing - Sheet Metal Work Manufacturing - Ornamental and Architectural Metal Work Manufacturing - Metal Coating, Engraving, and Allied Services to Manufacturers	- Iron and Steel Pipe and Tube Manufacturing from Purchased Steel - Precision Turned Product Manufacturing - Bolt, Nut, Screw, Rivet, and Washer Manufacturing - Ball and Roller Bearing Manufacturing
Intermediate Inputs and Materials Manufacturing	Nonmetallic Mineral Product Manufacturing	- Clay Building Material and Refractories Manufacturing - Concrete Block and Brick Manufacturing	- Other Pressed and Blown Glass and Glassware Manufacturing - Abrasive Product Manufacturing - Mineral Wool Manufacturing
Technology and Advanced Manufacturing	Computer and Electronic Product Manufacturing	- Other Communications Equipment Manufacturing - Switchgear and Switchboard Apparatus Manufacturing	- Other Electronic Component Manufacturing - Electromedical and Electrotherapeutic Apparatus Manufacturing - Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing - Instruments Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables - Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals - Other Measuring and Controlling Device Manufacturing - Relay and Industrial Control Manufacturing

Theme	Subtheme	Industries in which WA shows a RCA and can grow in the intensive margin	Industries that WA can develop to foster growth on the extensive margin
Technology and Advanced Manufacturing	Health Product Manufacturing		- Surgical and Medical Instrument Manufacturing - Dental Laboratories
Technology and Advanced Manufacturing	Machinery Manufacturing	- Measuring, Dispensing, and Other Pumping Equipment Manufacturing - Conveyor and Conveying Equipment Manufacturing - Overhead Traveling Crane, Hoist, and Monorail System Manufacturing - Welding and Soldering Equipment Manufacturing	- Metal Valve Manufacturing - Ventilation, Heating, AC, and Refrigeration Equipment Manufacturing - Engine, Turbine, and Power Transmission Equipment Manufacturing - Sawmill, Woodworking, and Paper Machinery Manufacturing - Optical Instrument Manufacturing - Other Engine Equip. Manufacturing - Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing - Packaging Machinery Manufacturing - Fluid Power Pump and Motor Manufacturing
Technology and Advanced Manufacturing	Transportation Equipment Manufacturing		- Automobile Manufacturing - Motor Vehicle Body Manufacturing - Motor Vehicle Gasoline Engine and Engine Parts Manufacturing - Motor Vehicle Electrical and Electronic Equipment Manufacturing - Other Motor Vehicle Parts Manufacturing - Railroad Rolling Stock Manufacturing
Tourism	Educational Services	- Business and Secretarial Schools	- Computer Training - Fine Arts Schools - Sports and Recreation Instruction - Exam Preparation and Tutoring
Tourism	Food and Transportation	- Other Nonscheduled Air Transportation - Inland Water Passenger Transportation - Taxi Service - Charter Bus Industry - All Other Travel Arrangement and Reservation Services - Full-Service Restaurants	- Limousine Service - Caterers - Snack and Nonalcoholic Beverage Bars
Tourism	Health Services	- Offices of Podiatrists - Psychiatric and Substance Abuse Hospitals	- Offices of Dentists - Offices of Mental Health Practitioners (except Physicians) - Freestanding Ambulatory Surgical and Emergency Centers - Diagnostic Imaging Centers

Theme	Subtheme	Industries in which WA shows a RCA and can grow in the intensive margin	Industries that WA can develop to foster growth on the extensive margin
Professional Services	Consulting and Research Services	- Administrative Management and General Management Consulting Services	- Marketing Consulting Services - Other Management Consulting - Marketing Research and Public Opinion Polling - Executive Search Services
Professional Services	Engineering and Architectural Services	- Architectural Services - Engineering Services	- Landscape Architectural Services - Building Inspection Services
Professional Services	IT Services	- Computer Systems Design Services	- Software Publishers - Data Processing, Hosting, and Related Services - Custom Computer Programming Services - Other Computer Related Services
Professional Services	Legal Services	- Architectural Services - Engineering Services	- Offices of Lawyers - Offices of Notaries
Professional Services	Specialized Design Services	- Graphic Design Services	- Interior Design Services - Industrial Design Services

Source: Own construction.

Annex 4: Viability Factors Performance

NAICS Code	*Industry Description*	*RCA in WA*	*Av. RCA in Peers*	*Utility Intensity*	*Missing Occupations (#)*	*Missing Inputs (#)*
33291	Metal Valve Manufacturing	0.77	0.67	0.03	14	2
33341	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	0.81	0.89	0.02	18	5
33361	Engine, Turbine, and Power Transmission Equipment Manufacturing	0.24	0.57	0.02	15	6
111320	Citrus (except Orange) Groves	2.06	0.76	0.01	0	1
111336	Fruit and Tree Nut Combination Farming	37.15	9.12	0.01	0	1
114111	Finfish Fishing	2.52	19.92	0.01	0	2
114112	Shellfish Fishing	6.90	2.60	0.01	0	2
114119	Other Marine Fishing	15.98	3.55	0.01	0	2
311520	Ice Cream and Frozen Dessert Manufacturing	2.00	0.92	0.03	5	2
311920	Coffee and Tea Manufacturing	0.79	1.20	0.02	9	3
312120	Breweries	8.97	3.07	0.03	8	1
312230	Tobacco Manufacturing	6.43	0.48	0.01	1	11
325211	Plastics Material and Resin Manufacturing	0.25	0.43	0.04	23	1
325520	Adhesive Manufacturing	0.32	0.72	0.03	23	5
325998	All Other Miscellaneous Chemical Product and Preparation Manufacturing	1.02	0.67	0.03	18	5
327120	Clay Building Material and Refractories Manufacturing	1.34	0.65	0.03	12	4

327212	Other Pressed and Blown Glass and Glassware Manufacturing	0.30	0.40	0.05	0	5
327331	Concrete Block and Brick Manufacturing	2.09	1.62	0.03	12	3
327910	Abrasive Product Manufacturing	0.38	0.24	0.02	17	8
327993	Mineral Wool Manufacturing	0.12	0.77	0.06	6	4
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel	1.37	0.49	0.04	15	5
331221	Rolled Steel Shape Manufacturing	10.74	2.56	0.04	15	8
332321	Metal Window and Door Manufacturing	4.01	1.94	0.03	14	13
332322	Sheet Metal Work Manufacturing	1.66	1.11	0.03	14	5
332323	Ornamental and Architectural Metal Work Manufacturing	1.83	1.12	0.03	14	5
332721	Precision Turned Product Manufacturing	0.00	0.25	0.03	14	8
332722	Bolt, Nut, Screw, Rivet, and Washer Manufacturing	0.75	0.53	0.03	14	4
332812	Metal Coating, Engraving (except Jewelry and Silverware), and Allied Services to Manufacturers	1.00	1.20	0.04	13	6
332991	Ball and Roller Bearing Manufacturing	0.04	0.17	0.03	14	5
333243	Sawmill, Woodworking, and Paper Machinery Manufacturing	0.36	1.09	0.02	18	6
333314	Optical Instrument and Lens Manufacturing	0.09	0.91	0.02	23	6

333618	Other Engine Equipment Manufacturing	0.15	0.86	0.02	15	2
333914	Measuring, Dispensing, and Other Pumping Equipment Manufacturing	1.23	0.64	0.02	18	2
333922	Conveyor and Conveying Equipment Manufacturing	1.72	0.94	0.02	18	2
333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	1.07	1.34	0.02	18	2
333924	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing	0.70	0.58	0.02	12	2
333992	Welding and Soldering Equipment Manufacturing	2.24	0.83	0.02	18	4
333993	Packaging Machinery Manufacturing	0.31	0.64	0.02	23	3
333996	Fluid Power Pump and Motor Manufacturing	0.20	0.24	0.02	15	9
334290	Other Communications Equipment Manufacturing	1.17	1.10	0.01	13	3
334419	Other Electronic Component Manufacturing	0.24	0.93	0.02	22	9
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing	0.01	0.76	0.01	40	2
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	0.03	0.61	0.01	40	4

334513	Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables	0.23	0.57	0.01	40	4
334515	Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals	0.05	1.14	0.01	40	4
334519	Other Measuring and Controlling Device Manufacturing	0.29	0.74	0.01	40	6
335313	Switchgear and Switchboard Apparatus Manufacturing	1.33	0.91	0.02	20	4
335314	Relay and Industrial Control Manufacturing	0.18	0.72	0.01	20	3
336111	Automobile Manufacturing	0.28	0.51	0.02	3	2
336211	Motor Vehicle Body Manufacturing	1.29	0.72	0.02	12	7
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	0.00	0.24	0.03	23	6
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	0.03	0.28	0.03	23	12
336390	Other Motor Vehicle Parts Manufacturing	0.67	0.77	0.03	23	6
336510	Railroad Rolling Stock Manufacturing	0.52	1.29	0.02	7	6
337211	Wood Office Furniture Manufacturing	2.25	1.44	0.03	8	8
337212	Custom Architectural Woodwork and	0.00	1.01	0.03	17	2

	Millwork Manufacturing					
339112	Surgical and Medical Instrument Manufacturing	0.15	0.47	0.01	30	4
339116	Dental Laboratories	0.86	1.92	0.02	30	9
481219	Other Nonscheduled Air Transportation	1.84	1.98	0.01	11	4
483212	Inland Water Passenger Transportation	1.77	3.33	0.01	5	8
485310	Taxi Service	1.43	4.98	0.01	4	9
485320	Limousine Service	0.00	0.64	0.01	4	11
485510	Charter Bus Industry	4.10	2.40	0.01	2	4
511210	Software Publishers	0.07	0.92	0.01	8	2
518210	Data Processing, Hosting, and Related Services	0.06	0.79	0.02	16	1
541110	Offices of Lawyers	0.58	0.85	0.01	15	1
541120	Offices of Notaries	0.00	2.81	0.01	15	1
541310	Architectural Services	1.73	1.43	0.01	68	5
541320	Landscape Architectural Services	0.28	0.88	0.01	68	4
541330	Engineering Services	3.25	1.44	0.01	68	4
541350	Building Inspection Services	0.00	1.23	0.01	68	8
541410	Interior Design Services	0.00	0.91	0.01	20	1
541420	Industrial Design Services	0.00	1.31	0.01	20	3
541430	Graphic Design Services	3.34	1.71	0.01	20	3
541511	Custom Computer Programming Services	0.52	2.31	0.00	20	3
541512	Computer Systems Design Services	1.39	0.92	0.00	20	9

541519	Other Computer Related Services	0.00	0.39	0.01	20	2
541611	Administrative Management and General Management Consulting Services	1.94	1.24	0.01	70	4
541613	Marketing Consulting Services	0.00	0.46	0.01	70	5
541618	Other Management Consulting Services	0.89	1.17	0.01	70	5
541910	Marketing Research and Public Opinion Polling	0.11	1.29	0.01	31	1
561312	Executive Search Services	0.00	0.26	0.00	51	1
561599	All Other Travel Arrangement and Reservation Services	1.66	1.18	0.01	7	1
611410	Business and Secretarial Schools	1.29	0.67	0.01	23	3
611420	Computer Training	0.53	0.58	0.01	23	3
611610	Fine Arts Schools	0.75	1.18	0.01	35	12
611620	Sports and Recreation Instruction	0.16	1.37	0.01	35	12
611691	Exam Preparation and Tutoring	0.00	0.84	0.01	35	12
621210	Offices of Dentists	0.83	1.23	0.01	14	12
621330	Offices of Mental Health Practitioners (except Physicians)	0.00	0.83	0.01	65	4
621391	Offices of Podiatrists	2.40	0.98	0.02	65	4
621493	Freestanding Ambulatory Surgical and Emergency Centers	0.00	0.40	0.01	89	4

621512	Diagnostic Imaging Centers	0.00	0.73	0.02	31	1
622210	Psychiatric and Substance Abuse Hospitals	4.06	0.83	0.03	59	6
722320	Caterers	0.00	0.87	0.03	17	3
722511	Full-Service Restaurants	1.90	1.34	0.03	16	4
722515	Snack and Nonalcoholic Beverage Bars	0.00	1.07	0.03	16	4

Annex 5: Attractiveness Factors Performance

NAICS Code	*Industry Description*	*Average Wages (USD)*	*Remoteness Coefficient*	*FDI - Total (USD MM)*	*FDI - Knowledge Intensive (USD MM)*	*Export Propensity*
33291	Metal Valve Manufacturing	46,150	0.12	10,277	317	24.2%
33341	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	46,150	0.22	13,335	2,095	26.3%
33361	Engine, Turbine, and Power Transmission Equipment Manufacturing	49,740	0.10	55,068	7,863	27.6%
111320	Citrus (except Orange) Groves	32,300	-0.08	387	21	18.8%
111336	Fruit and Tree Nut Combination Farming	32,300	-0.07	696	38	8.0%
114111	Finfish Fishing	32,300	-0.11	213	6	16.4%
114112	Shellfish Fishing	32,300	-0.07	153	4	22.6%
114119	Other Marine Fishing	32,300	-0.09	121	4	13.0%
311520	Ice Cream and Frozen Dessert Manufacturing	40,290	0.19	4,990	93	11.4%
311920	Coffee and Tea Manufacturing	35,370	-0.03	9,102	399	20.7%
312120	Breweries	36,710	0.03	28,884	587	11.4%
312230	Tobacco Manufacturing	45,900	0.11	13,270	682	9.9%
325211	Plastics Material and Resin Manufacturing	56,490	0.38	4,315	145	21.8%
325520	Adhesive Manufacturing	56,490	0.30	57,531	2,912	18.9%
325998	All Other Miscellaneous Chemical Product and Preparation Manufacturing	56,490	0.23	13,982	1,535	18.9%
327120	Clay Building Material and Refractories Manufacturing	40,190	0.30	6,825	273	16.7%

327212	Other Pressed and Blown Glass and Glassware Manufacturing	40,190	0.17	12,196	163	33.9%
327331	Concrete Block and Brick Manufacturing	40,190	0.32	14,880	49	4.6%
327910	Abrasive Product Manufacturing	40,190	0.17	1,380	122	29.0%
327993	Mineral Wool Manufacturing	40,190	0.12	1,624	144	9.1%
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel	42,060	0.17	68,420	432	23.8%
331221	Rolled Steel Shape Manufacturing	42,060	0.24	75,576	477	14.7%
332321	Metal Window and Door Manufacturing	41,230	0.21	1,227	63	12.2%
332322	Sheet Metal Work Manufacturing	41,230	0.47	803	42	33.9%
332323	Ornamental and Architectural Metal Work Manufacturing	41,230	0.20	454	24	20.0%
332721	Precision Turned Product Manufacturing	42,400	0.28	3,636	163	16.9%
332722	Bolt, Nut, Screw, Rivet, and Washer Manufacturing	42,400	0.19	6,102	273	21.7%
332812	Metal Coating, Engraving (except Jewelry and Silverware), and Allied Services to Manufacturers	35,480	0.35	2,277	20	14.9%
332991	Ball and Roller Bearing Manufacturing	41,230	0.18	5,274	163	27.3%
333243	Sawmill, Woodworking, and Paper Machinery Manufacturing	46,150	0.17	313	13	24.8%
333314	Optical Instrument and Lens Manufacturing	48,950	0.07	377	64	49.9%

333618	Other Engine Equipment Manufacturing	49,740	0.13	9,839	1,278	34.2%
333914	Measuring, Dispensing, and Other Pumping Equipment Manufacturing	46,150	0.09	4,266	759	20.9%
333922	Conveyor and Conveying Equipment Manufacturing	46,150	0.31	3,159	562	22.1%
333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	46,150	0.16	3,397	605	18.3%
333924	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing	46,150	0.14	2,092	372	36.1%
333992	Welding and Soldering Equipment Manufacturing	46,150	0.07	3,297	587	18.7%
333993	Packaging Machinery Manufacturing	46,150	0.18	2,794	497	23.1%
333996	Fluid Power Pump and Motor Manufacturing	46,150	0.10	1,643	292	35.3%
334290	Other Communications Equipment Manufacturing	68,050	0.18	32,417	11,663	23.3%
334419	Other Electronic Component Manufacturing	57,010	0.28	139,912	19,035	34.7%
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing	68,820	0.13	14,641	5,721	50.8%
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	68,820	0.11	2,091	736	16.6%

334513	Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables	68,820	0.22	910	320	20.3%
334515	Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals	68,820	0.03	1,708	601	15.2%
334519	Other Measuring and Controlling Device Manufacturing	68,820	0.15	3,687	1,297	23.1%
335313	Switchgear and Switchboard Apparatus Manufacturing	46,430	0.17	4,436	1,034	22.4%
335314	Relay and Industrial Control Manufacturing	46,430	0.32	4,230	986	19.9%
336111	Automobile Manufacturing	54,810	0.15	517,327	35,212	32.3%
336211	Motor Vehicle Body Manufacturing	38,100	0.19	21,270	959	27.1%
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	39,450	0.13	81,723	4,082	37.7%
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	39,450	0.23	41,807	4,287	45.9%
336390	Other Motor Vehicle Parts Manufacturing	39,450	0.56	72,824	7,267	25.7%
336510	Railroad Rolling Stock Manufacturing	44,430	0.18	22,843	1,013	17.2%
337211	Wood Office Furniture Manufacturing	35,510	0.13	1,747	80	25.9%
337212	Custom Architectural Woodwork and	35,510	0.19	733	33	34.7%

	Millwork Manufacturing					
339112	Surgical and Medical Instrument Manufacturing	43,640	0.18	14,128	3,049	28.7%
339116	Dental Laboratories	43,640	0.26	3,315	715	3.0%
481219	Other Nonscheduled Air Transportation	60,730	-0.08	8,758	144	6.0%
483212	Inland Water Passenger Transportation	49,090	-0.01	4,734	102	3.5%
485310	Taxi Service	28,500	0.30	135	8	0.2%
485320	Limousine Service	28,500	0.26	34	2	0.9%
485510	Charter Bus Industry	32,330	0.24	69	4	1.7%
511210	Software Publishers	95,030	0.13	206,113	67,173	5.0%
518210	Data Processing, Hosting, and Related Services	72,320	0.19	174,514	4,125	6.2%
541110	Offices of Lawyers	60,460	0.25	9,465	212	1.6%
541120	Offices of Notaries	60,460	0.16	705	16	1.4%
541310	Architectural Services	70,400	0.17	2,259	213	2.1%
541320	Landscape Architectural Services	70,400	0.46	854	80	1.3%
541330	Engineering Services	70,400	0.22	6,517	613	4.3%
541350	Building Inspection Services	70,400	0.40	163	15	1.6%
541410	Interior Design Services	52,260	0.21	183	16	6.0%
541420	Industrial Design Services	52,260	0.15	66	6	16.1%
541430	Graphic Design Services	52,260	0.26	327	29	2.7%
541511	Custom Computer Programming Services	86,380	0.18	80,774	28,240	9.2%
541512	Computer Systems Design Services	86,380	0.29	10,386	5,043	2.2%

541519	Other Computer Related Services	86,380	0.19	1,638	418	18.2%
541611	Administrative Management and General Management Consulting Services	64,630	0.24	5,745	290	7.7%
541613	Marketing Consulting Services	64,630	0.19	455	23	3.9%
541618	Other Management Consulting Services	64,630	0.06	3,418	172	7.8%
541910	Marketing Research and Public Opinion Polling	37,460	0.17	4,769	1,166	5.3%
561312	Executive Search Services	30,060	0.23	1,228	56	1.8%
561599	All Other Travel Arrangement and Reservation Services	40,070	0.19	546	131	15.8%
611410	Business and Secretarial Schools	56,420	0.19	1,661	121	0.3%
611420	Computer Training	56,420	0.20	1,679	122	0.8%
611610	Fine Arts Schools	36,390	0.32	9,588	572	0.5%
611620	Sports and Recreation Instruction	36,390	0.27	2,025	77	1.0%
611691	Exam Preparation and Tutoring	36,390	0.25	2,025	77	4.4%
621210	Offices of Dentists	47,210	0.21	523	44	0.4%
621330	Offices of Mental Health Practitioners (except Physicians)	44,380	0.25	190	16	0.2%
621391	Offices of Podiatrists	44,380	0.65	83	7	0.3%
621493	Freestanding Ambulatory Surgical and Emergency Centers	49,900	0.21	303	133	0.5%

621512	Diagnostic Imaging Centers					
622210	Psychiatric and Substance Abuse Hospitals	45,300	0.26	1,728	759	0.5%
	Caterers					
722511	Full-Service Restaurants	22,590	0.13	1,583	213	0.6%
	Snack and Nonalcoholic Beverage Bars					

Annex 6: Methodology for Assessing Access to Occupations

One of the key determinants of the development of any productive activity in a certain location is the availability of workers that can fill the appropriate occupations that are required in that industry. Therefore, determining the availability of the right occupations in a certain location is critical to determining whether that industry is viable in that location. In view of its relevance, the Growth Lab developed a methodology to measure whether an occupation is available or not in a certain location, based on information from the U.S. Bureau of Labor Statistics on occupational vectors needed per industry. As noted earlier in the report, using data from the U.S. economy is useful not only because the country has accessible and reliable databases but because it also displays an advanced productive structure and a wide collection of industries, which can provide a good approximation of how individual industries would interact with each other if and when they are fully developed in WA.

The main idea of this methodology is the assumption that an occupation is available in a certain location if there are other industries that already exist in that location that also require the occupation in an important way. The methodology first identifies which occupations are demanded more importantly by the industries of interest comparatively to other occupations. To this end, an RCA in the demand of a certain occupation is calculated for every industry. This indicator is analogous to the one used to measure the intensity to which an industry is developed in the country. The calculation is as follows: the percentage of the total employment in a particular occupation for a certain industry, is divided by the percentage of the total employment in that occupation for the entire economy. If this RCA is equal or greater than one, the occupation is demanded "intensively" by the industry in question, relative to the rest of the economy. Next, to assess whether the occupations intensively required by the diversification opportunities identified are available in WA, we count the number of industries that intensively demand the same occupation and have already been identified as present in the country (according to RCA). If a sufficiently large number (10 or more) of industries meet this criterion, then the occupation is also considered to be available. In short, the methodology presumes that an occupation is available in WA if a sufficiently large number of industries that intensively demand it are intensively present in WA.

The result of this exercise is a list of the occupations that are intensively demanded by each diversification opportunity, which can be classified either as available or missing. Performance on this factor is measured by the total number of occupations that are intensively required by the industry in question and are considered to be missing or not accessible in WA.

Annex 7: Methodology for Estimating Missing Inputs

An important element for the development of any productive activity is firms' capacity to access the intermediate inputs required in the production process, which are usually supplied by third parties, whether domestic or imported. The ability to access intermediate inputs in a given location is critical to determine the viability of an industry. It is important to note that for an intermediate input to be available in a particular location, it is not necessary that the industries that offer the input exist in the same location, as it is sufficient that the input is accessible through imports (to the extent that the input is tradable). In view of its relevance, the Growth Lab developed a methodology to measure a particular country's performance on this factor, based on information from U.S. Input-Output tables. As noted in the report, using data from the U.S. economy is useful not only because the country has accessible and reliable databases but because it also displays an advanced productive structure and a wide collection of industries, which can provide a good approximation of how individual industries would interact with each other if and when they are fully developed in WA.

The methodology first identifies which goods and services are intensively required by the industries of interest. To this end, an RCA in the use of the different inputs (RCAI) is calculated for every industry. This indicator is analogous to the one used to measure the intensity to which an industry is developed in the country. In the case of the RCAI, the calculation is as follows: the percentage of the total demand for inputs of the specific industry that is given by a particular input is divided by the percentage of the total demand for inputs in the economy that is given by that same input. If the RCAI is equal or greater than one, the input is demanded intensively by the industry in question, relative to the rest of the economy. Next, to assess whether the inputs intensively required by the diversification opportunities identified are available in WA, a combination of two tests are applied. The first test evaluates if the input, an industry in itself, is present in the country. For this, the traditional RCA measure is used. If the industry shows an RCA equal or greater than one, then the input that it offers is considered to be available. If this is not the case, the second test evaluates if other industries that intensively demand the same input are present in the country (using RCA). If a sufficiently large number (20 or more) of industries meet this criterion, then the input is also considered to be available. In short, the methodology presumes that an input is available in WA if it comes from an industry that is intensively present in WA or if a sufficiently large number of industries that intensively demand it are intensively present in WA.

The result of this exercise is a list of the intermediate inputs that are intensively demanded by each diversification opportunity, which can be classified either as available or missing. Performance on this factor is measured by the total number of inputs that are intensively required by the industry in question that are considered to be missing or not accessible in WA.

Annex 8: Methodology for Estimating Foreign Direct Investment

Among the attractiveness factors that are considered in the prioritization exercise, two measures of Foreign Direct Investment (FDI) flows at the worldwide level are considered. The first is total FDI, and the second is FDI in knowledge intensive activities. Because the fDi markets subsectors are in most cases more aggregated than a NAICS six-digit level industry, to assign an estimate of FDI flows to each NAICS industry that was selected based on the complexity analysis we estimated weights based on employment according to the Dun & Bradstreet (D&B) dataset.

Although the subsectors in fDi markets are based on the NAICS 2007 classification, the match between NAICS and these subsectors is made at different levels of disaggregation. This means that some of the fDi markets categories match to NAICS at a six-digit level, and some match at a three-digit level. For the categories that match fully to a NAICS six-digit level industry, the full FDI flow from that category is assigned to the selected NAICS industry. For the NAICS industries that do not match with an fDi category at the six-digit level, only a part of the matched fDi category is assigned based on weights calculated from D&B. Weights are calculated based on the proportion of employment in the NAICS6 industry to the employment in the NAICS3 or NAICS4 category that matched with the fDi subsector. An example may help to illustrate this. The closest match to the NAICS6 industry “Fruit and tree nut combination farming” (NAICS 111336) is the fDi subsector “Crop production” (NAICS 111). However, the latter clearly includes a wider range of industries than the former. An assignment of all of the FDI in this subsector to NAICS industry 111336 would likely be an overstatement. Therefore, the amount of FDI in “Crop production,” is weighted by the proportion of employment in NAICS 111336 to NAICS 111 (namely, “Crop production”) to get a measure of the FDI spent only on fruit and tree nut combination farming.

This implies an assumption that total employment in an industry is proportional to the total FDI in that industry. As an important caveat, this may not be true across industries that have different levels of capital intensity. However, this approximation leads to higher variability in the assignment of FDI to the NAICS6 industries, which is important for the purposes of the analysis. Both total FDI flows and knowledge intensive FDI flows are assigned in this way. Knowledge intensive FDI flows are defined based on projects that either set up “headquarters” or are involved in “research and development” or “design, development and testing” activities (based on the “industry activity” variable in the fDi markets dataset).

Annex 9: Match Between Diversification Opportunities and Regions

The following table lists example economic diversification opportunities for various regions of WA. Importantly, not all of these opportunities are necessarily export industries; they also include domestic-facing industries that could drive employment growth.

NAICS	Description	Region 1	Region 2	Region 3
33291	Metal Valve Manufacturing	Perth	Goldfields-Esperance	South West
33341	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	Perth	Peel	Pilbara
33361	Engine, Turbine, and Power Transmission Equipment Manufacturing	Peel	Perth	Kimberley
111320	Citrus (except Orange) Groves	Gascoyne	Wheat Belt	South West
111336	Fruit and Tree Nut Combination Farming	Kimberley	Gascoyne	South West
114111	Finfish Fishing	Great Southern	Perth	Wheat Belt
114112	Shellfish Fishing	Mid West	Perth	Wheat Belt
114119	Other Marine Fishing	Gascoyne	Kimberley	Mid West
311520	Ice Cream and Frozen Dessert Manufacturing	Gascoyne	South West	Perth
311920	Coffee and Tea Manufacturing	Perth	South West	Wheat Belt
312120	Breweries	Gascoyne	Great Southern	Perth
312230	Tobacco Manufacturing	South West	Perth	Wheat Belt
325211	Plastics Material and Resin Manufacturing	Wheat Belt	Perth	South West
325520	Adhesive Manufacturing	South West	Perth	Wheat Belt
325998	All Other Miscellaneous Chemical Product and Preparation Manufacturing	Pilbara	Perth	Wheat Belt
327120	Clay Building Material and Refractories Manufacturing	Perth	South West	Peel
327212	Other Pressed and Blown Glass and Glassware Manufacturing	Perth	South West	Great Southern

327331	Concrete Block and Brick Manufacturing	Kimberley	Perth	Mid West
327910	Abrasive Product Manufacturing	Perth	Wheat Belt	South West
327993	Mineral Wool Manufacturing	Great Southern	Perth	South West
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel	Perth	South West	Wheat Belt
331221	Rolled Steel Shape Manufacturing	Peel	Wheat Belt	South West
332321	Metal Window and Door Manufacturing	Perth	Great Southern	Peel
332322	Sheet Metal Work Manufacturing	Peel	Kimberley	Perth
332323	Ornamental and Architectural Metal Work Manufacturing	Peel	Mid West	Perth
332721	Precision Turned Product Manufacturing	South West	Wheat Belt	Perth
332722	Bolt, Nut, Screw, Rivet, and Washer Manufacturing	Perth	South West	Wheat Belt
332812	Metal Coating, Engraving (except Jewelry and Silverware), and Allied Services to Manufacturers	Kimberley	Perth	South West
332991	Ball and Roller Bearing Manufacturing	Perth	South West	Wheat Belt
333243	Sawmill, Woodworking, and Paper Machinery Manufacturing	Goldfields-Esperance	Pilbara	Perth
333314	Optical Instrument and Lens Manufacturing	Perth	Wheat Belt	South West
333914	Measuring, Dispensing, and Other Pumping Equipment Manufacturing	Goldfields-Esperance	Mid West	South West
333922	Conveyor and Conveying Equipment Manufacturing	South West	Perth	Peel
333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	Goldfields-Esperance	Pilbara	Perth
333924	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing	Pilbara	Wheat Belt	Mid West
333992	Welding and Soldering Equipment Manufacturing	Wheat Belt	Kimberley	Great Southern
333993	Packaging Machinery Manufacturing	Perth	South West	Wheat Belt
333996	Fluid Power Pump and Motor Manufacturing	Perth	South West	Wheat Belt

334290	Other Communications Equipment Manufacturing	Perth	South West	Wheat Belt
334419	Other Electronic Component Manufacturing	Perth	South West	Wheat Belt
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing	Perth	South West	Wheat Belt
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	Perth	Wheat Belt	South West
334513	Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables	Perth	South West	Wheat Belt
334515	Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals	Perth	Wheat Belt	Pilbara
334519	Other Measuring and Controlling Device Manufacturing	Goldfields-Esperance	Perth	South West
335313	Switchgear and Switchboard Apparatus Manufacturing	Perth	Mid West	Great Southern
335314	Relay and Industrial Control Manufacturing	Perth	Wheat Belt	South West
336111	Automobile Manufacturing	Perth	Wheat Belt	South West
336211	Motor Vehicle Body Manufacturing	South West	Perth	Wheat Belt
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	Perth	South West	Wheat Belt
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	Perth	South West	Wheat Belt
336390	Other Motor Vehicle Parts Manufacturing	Great Southern	Perth	South West
336510	Railroad Rolling Stock Manufacturing	Gascoyne	Perth	South West
337211	Wood Office Furniture Manufacturing	Perth	Wheat Belt	South West
337212	Custom Architectural Woodwork and Millwork Manufacturing	South West	Wheat Belt	Perth
339112	Surgical and Medical Instrument Manufacturing	Perth	Peel	South West
339116	Dental Laboratories	Perth	Mid West	South West
481219	Other Nonscheduled Air Transportation	Kimberley	Gascoyne	Pilbara
483212	Inland Water Passenger Transportation	Gascoyne	Kimberley	Perth

485310	Taxi Service	Pilbara	Gascoyne	Mid West
485320	Limousine Service	South West	Wheat Belt	Goldfields-Esperance
485510	Charter Bus Industry	Goldfields-Esperance	Kimberley	Pilbara
511210	Software Publishers	Perth	South West	Wheat Belt
518210	Data Processing, Hosting, and Related Services	Wheat Belt	Perth	South West
541110	Offices of Lawyers	Great Southern	Perth	Peel
541120	Offices of Notaries	South West	Wheat Belt	Perth
541310	Architectural Services	Perth	Great Southern	Mid West
541320	Landscape Architectural Services	Kimberley	Pilbara	Perth
541330	Engineering Services	Goldfields-Esperance	Mid West	Perth
541350	Building Inspection Services	South West	Wheat Belt	Perth
541410	Interior Design Services	South West	Wheat Belt	Great Southern
541420	Industrial Design Services	South West	Wheat Belt	Pilbara
541430	Graphic Design Services	Perth	Peel	South West
541511	Custom Computer Programming Services	Perth	Peel	South West
541512	Computer Systems Design Services	Perth	Peel	South West
541519	Other Computer Related Services	South West	Wheat Belt	Perth
541611	Administrative Management and General Management Consulting Services	Perth	Peel	South West
541613	Marketing Consulting Services	South West	Wheat Belt	Perth
541618	Other Management Consulting Services	Pilbara	Perth	Mid West
541910	Marketing Research and Public Opinion Polling	Perth	South West	Wheat Belt

561312	Executive Search Services	Wheat Belt	South West	Pilbara
561599	All Other Travel Arrangement and Reservation Services	Gascoyne	Kimberley	Mid West
611410	Business and Secretarial Schools	Perth	Wheat Belt	South West
611420	Computer Training	Goldfields-Esperance	Peel	Perth
611610	Fine Arts Schools	Mid West	Perth	Pilbara
611620	Sports and Recreation Instruction	Gascoyne	Goldfields-Esperance	Perth
611691	Exam Preparation and Tutoring	South West	Wheat Belt	Great Southern
621210	Offices of Dentists	Peel	Perth	South West
621330	Offices of Mental Health Practitioners (except Physicians)	South West	Wheat Belt	Great Southern
621391	Offices of Podiatrists	Perth	Goldfields-Esperance	Mid West
621493	Freestanding Ambulatory Surgical and Emergency Centers	South West	Wheat Belt	Pilbara
621512	Diagnostic Imaging Centers	South West	Wheat Belt	Pilbara
622210	Psychiatric and Substance Abuse Hospitals	Perth	South West	Wheat Belt
722320	Caterers	South West	Wheat Belt	Perth
722511	Full-Service Restaurants	Perth	Peel	South West
722515	Snack and Nonalcoholic Beverage Bars	South West	Wheat Belt	Pilbara